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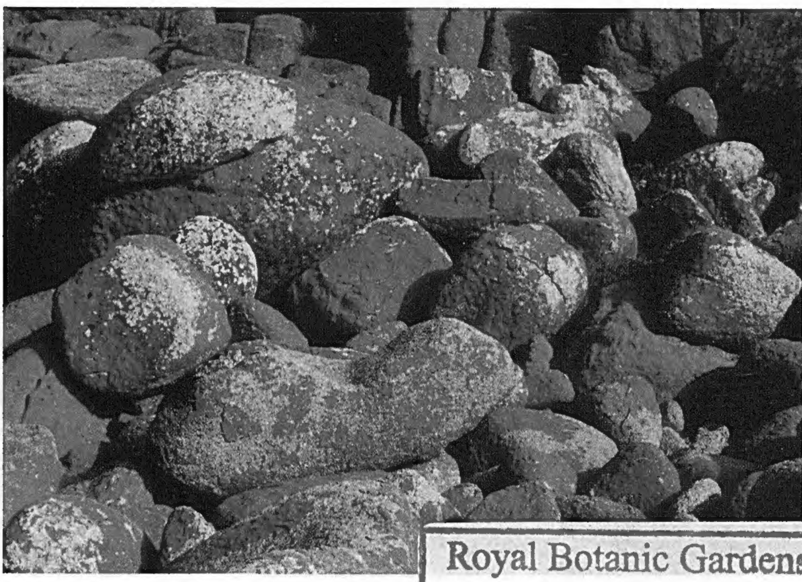

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Corrigendum

On page 180 of the most recent issue of *The Victorian Naturalist* (volume 135, no. 6) the date of the last known wombat to live in Warrnambool was incorrectly given as 'mid 1930s'. The date should have been '1954', which had been stated in an amendment to the manuscript. This error was due to an oversight on the part of the Editors, who accordingly apologise to the authors Rob Wallis and Elizabeth O'Callaghan.

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Front cover: *Caloplaca* at the western end of Egg Beach, Flinders Island. Photo John Whinray.
Back cover: Victorian dingo in a Darwin wildlife park. Photo Peter Menkhorst.

Three Antarctic ascidians from Four Ladies Bank: *Cnemidocarpa pfefferi* (Michaelsen, 1898), *Pyura discoveryi* (Herdman, 1910) and *Bathypera splendens* Michaelsen, 1904

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Abstract
Ascidians (sea squirts) from Australian Antarctic Territory have received little attention. We identified three species of Antarctic ascidian found among holothurians (sea cucumbers) collected from Prydz Bay, and curated at Museums Victoria. We provide descriptions of *Cnemidocarpa pfefferi* (Michaelsen, 1898), *Pyura discoveryi* (Herdman, 1910) and *Bathypera splendens* Michaelsen, 1904, and discuss their adaptations to the Antarctic environment. (*The Victorian Naturalist*, 136 (1), 2019, 4–16)

Key words: Ascidians, *Cnemidocarpa pfefferi*, *Pyura discoveryi*, *Bathypera splendens*, Australian Antarctic Territory

Introduction

While Antarctic ascidians (sea squirts) have been studied since the early 19th century, few investigations have been made of ascidians on the east coast of Antarctica in Australian Territory (Fig. 1) (Primo and Vásquez 2009; Schories *et al.* 2015). The specimens under discussion, *Cnemidocarpa pfefferi* (Michaelsen, 1898), *Pyura discoveryi* (Herdman, 1910) and *Bathypera splendens* Michaelsen, 1904, were identified among holothurians (sea cucumbers) curated at Museums Victoria (NMV) (P Mark O'Loughlin, pers. comm., 21 August 2017). The sample was collected during Voyage 5 (BRAD) 1996/97 by Research Survey Vessel *Aurora Australis*, in the Marine Benthos Program investigating the Antarctic continental shelf in Prydz Bay (Bardsley 1997; Bathie and Pett 2019a).

Prydz Bay is a deep embayment where the giant drainage system of Lambert Glacier ends at the Amery Ice Shelf (Fig. 2). From its deepest at 700 m in the Amery Depression, the sea floor rises gently to Four Ladies Bank, a shelf bank at a depth of 100–200 m (Mackintosh *et al.* 2014). Much of this sea floor consists of fine mud and biosiliceous ooze (O'Brien *et al.* 2014). Most areas of Prydz Bay shallower than 690 m show iceberg ploughmarks (O'Brien *et al.* 1997), some of which are probably relict features from previous glaciation (Harris *et al.* 1998), but others may have been freshly made by large modern icebergs (O'Brien *et al.* 2016). The ascidians described below were collected from the western slope of Four Ladies Bank (Quilty 1997), where sediment of gravelly sandy mud is thickly deposited (Harris *et al.* 1998). For a note on the naming of Four Ladies Bank see Bathie and Pett (2019b).

Materials and Methods

Specimens were collected by T Bardsley, R Ickeringill and C Hayward on 7 March 1997, from Station number AA97–26, 67°26.58'S, 76°38.74'E to 67°77'S, 76°38.89'E at a depth of 320 m, using beam trawling from *Aurora Australis*, Research Survey Vessel for Australian National Antarctic Research Expedition.

Specimens were preserved in 70% ethanol. The accession number is 1997/10.

Specimens examined

NMVF243197 1997/10C
Two oval specimens, greyish white, pleated test, cross-shaped siphons terminal (Figs 3A, 3C).

NMVF241317 1997/10A
Fourteen specimens of various sizes, extended divergent siphons, lumpy tunics with a few adherents and threadlike extensions on the base (Figs 3A, 3B).

NMVF241318 1997/10B
Three specimens, siphons widely spaced with flat, slit-like apertures. Tunics free of adherents

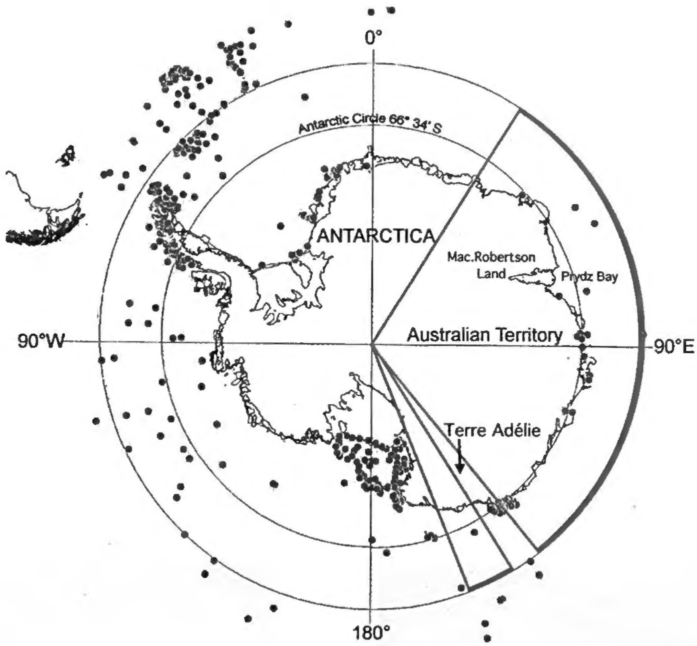

Fig. 1. Locations of ascidians (blue dots) collected between 1866 and 2013 in the South Polar Province. After Primo and Vázquez (2009) and Schories *et al.* (2015).

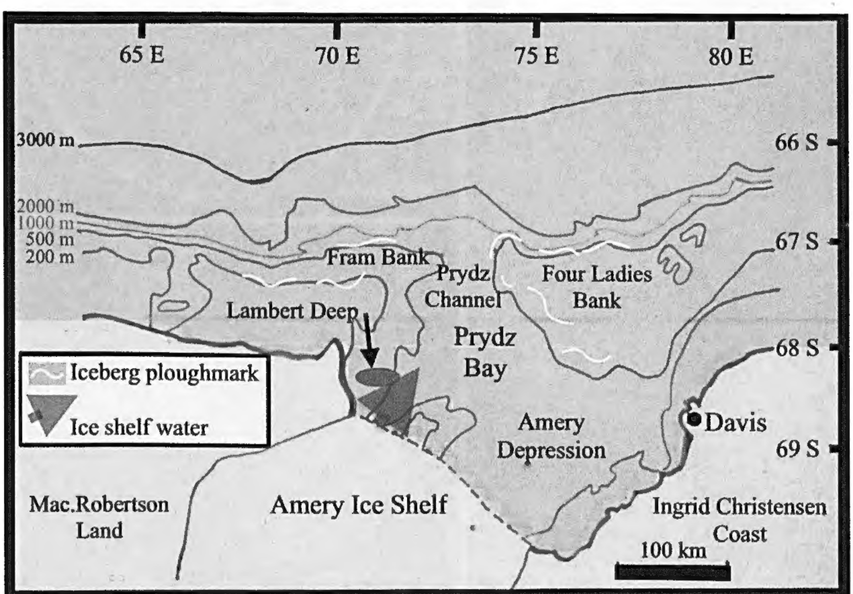

Fig. 2. Summary of bathymetry, iceberg ploughmarks and geographic features around Prydz Bay. After Harris *et al.* (1998) and O'Brien *et al.* (2016).

but apparently covered with very small bumps. Rounded shapes (Fig. 3C).

Examination

Internal features were examined using a WILD M5 Heerbrugg dissecting microscope and a Zeiss Axiolab light microscope. Images were captured with a Nikon Coolpix AW110 or an Olympus TG4. Drawings were made from images, notes or reference material. Taxonomic authority: World Register of Marine Species (WoRMS).

Results

The specimens identified belong to the suborder Stolidobranchia, one species from the family Styelidae (simple tentacles, more than one gonad on each side of the body), and two from the family Pyuridae (branched tentacles, only one gonad on each side) (Kott 1985).

The Stolidobranch ascidian

The following description is derived largely from Rocha's *Glossary of Tunicate Terminology* (2011). Fig. 4A incorporates the features below into a generic ascidian drawn by Kott (1969).

Ascidians (Class Ascidiacea), also known as tunicates or sea squirts, are marine invertebrates that are sessile suspension feeders and usually attached to a substrate. A protective fibrous tunic encases the body and provides the attachment point. Ascidians have two apertures: the branchial siphon draws large quantities of water into the body to filter food, and the atrial siphon is the exit point for waste and for larval dispersal. Siphons, usually divergent, may be close, or distant from each other. Branchial tentacles at the base of the branchial siphon prevent large particles from entering the body, and can be simple or compound (branched)

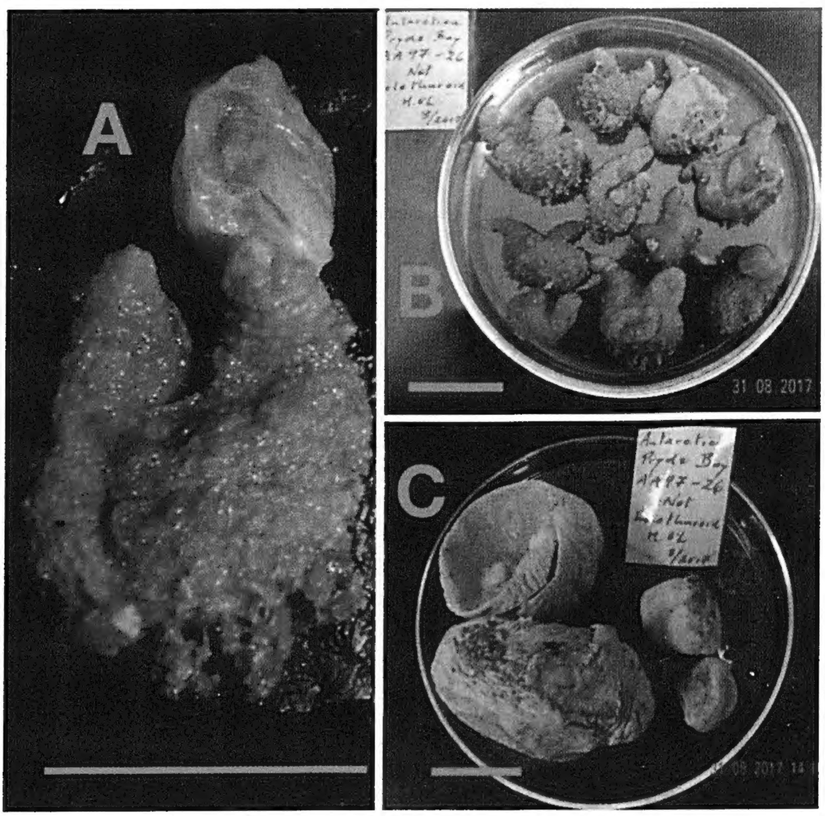

Fig. 3. A. NMVF243197 attached to siphon of NMVF241317. **B.** NMVF241317. **C.** NMVF241318 (three specimens) NMVF243197 (lower right specimen). Photos J Pett. Scale bars 35 mm.

(Fig. 4C). Surrounding the base of the siphons are circular muscle bands, from which longitudinal muscle bands radiate around the body. Water entering the siphon passes through the perforated branchial sac, where food filtration occurs. The order Stolidobranchia is defined by folds in the branchial sac which increase the filtering surface. In Stolidobranchs, the dorsal tubercle is a ciliated funnel opening into a duct connected to the neural gland. It appears in the peritubercular area as a small slit or coiled opening protruding above the branchial sac. Having passed through the branchial tentacles—simple (family Styelidae) or compound (family Pyuridae)—food particles are filtered by ciliated stigmata (perforations) (Fig. 4B) of the branchial sac, gathered by a mucus lining of the grooved endostyle and carried toward the midline of the body. The ciliated gutter of the dorsal lamina then delivers this food to the oesophagus and into the digestive tract. A liver or hepatic gland is present only in families Pyuridae and Molgulidae. Waste is eliminated through the anus (which has either a smooth or lobed margin) into the atrial cavity and then expelled via the atrial siphon. Most ascidians have both male and female gonads, which usually mature at different times to avoid self fertilisation (Kott 1997). Ova or sperm are released through gonoducts into the atrial cavity and released into the water column by the atrial siphon.

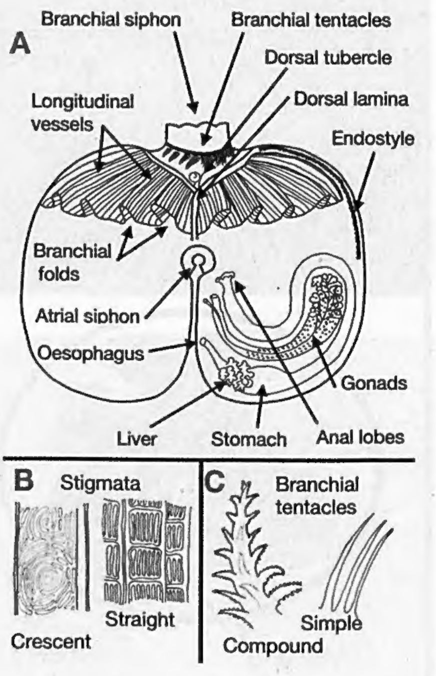

Fig. 4 A. Morphological characters of the Stolidobranch ascidian commonly used in descriptive taxonomy (Kott 1969) (adapted by C Bathie). **B.** Stigmata between longitudinal vessels can be straight or crescent-shaped. **C.** Branchial tentacles of Pyuridae and Styelidae are compound or simple respectively.

Descriptions

Cnemidocarpa pfefferi ***(Michaelsen, 1898) (Ascidiacea, Stolidobranchia, Styelidae)***

NMVF243197 1997/10C

The upright oval tunic (grey-white in preservative) is 18 mm high and 10 mm wide, and was attached to a siphon of a different ascidian (*Pyura discoveryi*). Longitudinal pleats end at cross-shaped apertures (Fig. 5) on short terminal siphons, directed away from each other. The test or outer covering is thin and paper-like, but strong, and almost transparent. The delicate body wall adheres to the test. Simple tentacles arise from a muscular ring around the branchial aperture. A muscular ring is also present around the atrial aperture. The peritubercular margin forms a sharp V. Inrolled horns of the dorsal tubercle form the heart shape described by Michaelsen (1898). There are four branchial folds on each side. Longitudinal vessels, dense on the folds but sparse between them, are folded and convoluted as per Kott (1969). Stigmata of the delicate branchial sac observed were long and narrow. The dorsal lamina is smooth and plain edged (Michaelsen 1898), and notably wider at one end. The oesophagus is long and narrow (Monniot *et al.* (2011). The stomach has 28 long folds. The wide and simple gut loop, not embedded in the body wall but attached only by ligaments (Monniot *et al.* 2011), is in this specimen distended, and occupies a large part of the body. Such an apparently swollen gut is visible through the test of the only other specimen. The rim of the conspicuous anus is smooth on one side, with eight paddle-shaped lobes on the other (Fig. 6). There are numerous small (1–2 mm) translucent endocarps on the body wall. There are two gonads on each side.

Unique to this species is a sinuous ovary with short paired lateral branches, the limbs curving towards each other as described by Millar (1960), and showing multiple terminal indentations (Fig. 7).

Pyura discoveryi ***(Herdman, 1910) (Ascidiacea, Stolidobranchia, Pyuridae)***
NMVF241317 1997/10A
Smallest 13 × 35 mm, largest 35 × 35 mm. As noted by Herdman (1923), length of the siphon is not necessarily proportional to length of the body. The anterior half of the test is notably free of adherents. Corrugations on the tough yellow -brown tunic form horizontal bands extending up long siphons with terminal four-lobed apertures. In common with other observers, we found no siphonal spines (Millar 1960). Short branchial tentacles have narrow primary and rudimentary secondary branches as per Kott (1969). A convoluted dorsal tubercle is readily visible (Fig. 8). An elongated, or 'serpentine' dorsal tubercle was considered by Herdman to be a remarkable and unmistakable characteristic of the species (1923); argument over the form of the dorsal tubercle was resolved by allowing that it becomes more complex with size *or* age (Van Name 1945). The dorsal lamina has long languets (tongues). The branchial sac has

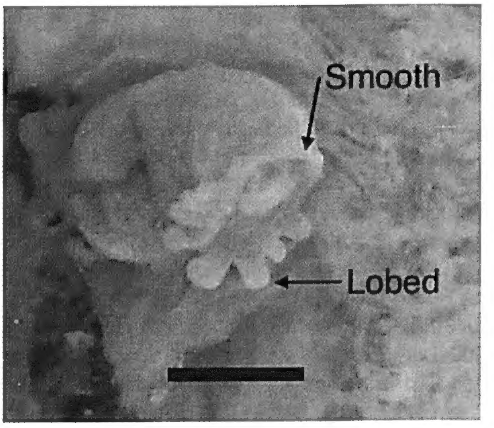

Fig. 6. *Cnemidocarpa pfefferi* anus is smooth on one side with 8 paddle-shaped lobes on the other side. Photo J Pett. Scale bar 2 mm.

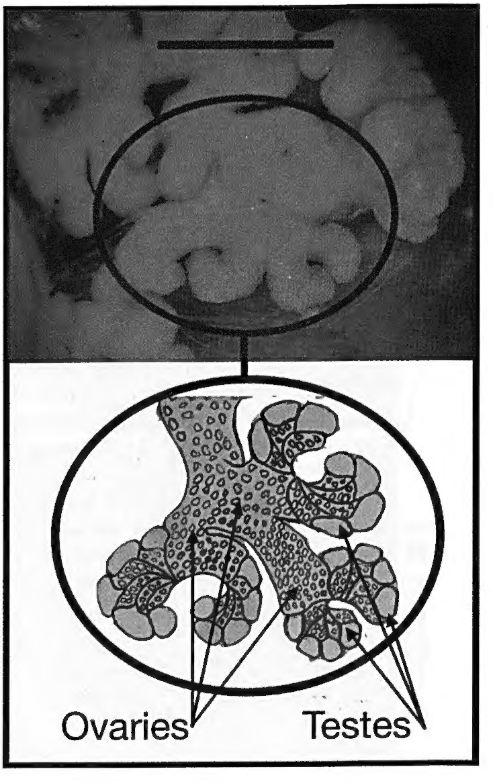

Fig. 7. *Cnemidocarpa pfefferi* ovaries and testes. Photo J Pett. Sketch C Bathie. Scale bar 2 mm.

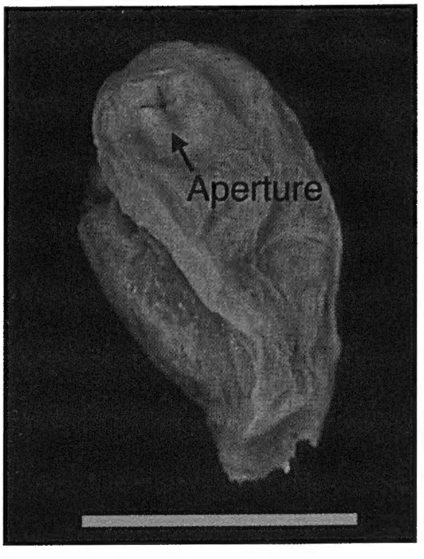

Fig. 5. Cross-shaped aperture of *Cnemidocarpa pfefferi*. Photo C Bathie. Scale bar 20 mm.

13 folds in total, consistent with modern descriptions of *Pyura discoveryi* (Monniot *et al.* 2011). Although Herdman (1923) observed only six distinct folds on each side, in small or young specimens a seventh fold may be present but represented by only a few longitudinal vessels (Van Name 1945), and easily overlooked (Kott 1969). We noted mesh with six regular oval stigmata but did not see spiral stigmata at the top of a fold as did Monniot *et al.* (2011). The gut loop is open with well-developed gonads on both sides of the body, each consisting of rounded masses along both sides of a central duct. The anus is lobed (Monniot *et al.* 2011) (Fig. 9).

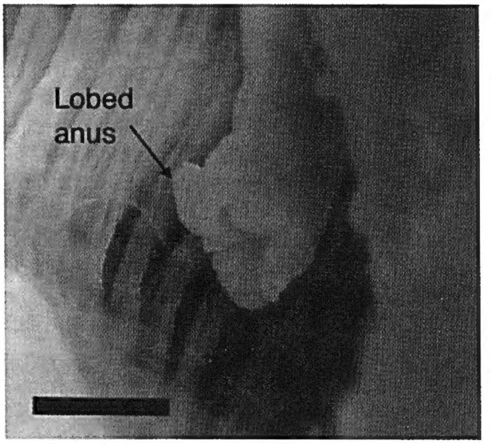

Fig. 9. Lobed anus of *Pyura discoveryi*. Photo J Pett. Scale bar 2 mm.

Bathypera splendens ***Michaelsen, 1904 (Ascidiacea, Stolidobranchia, Pyuridae)***
NMVF241318 1997/10B
The largest specimen is 65 mm wide and 65 mm high. The test is thin with no adherents and appears to be covered with tiny pimples. Siphons are short, with slit-like apertures distant from and perpendicular to each other (Fig. 10). Inside each slit, on each side, is a row of minute plates projecting into the aperture. Each specimen was attached to the substrate by a small area on the posterior end (Herdman 1923). The body was easy to remove from the test without damage (Monniot *et al.* 2011). There are six high branchial folds on each side. Stigmata are irregular crescent-shapes of various sizes (Kott

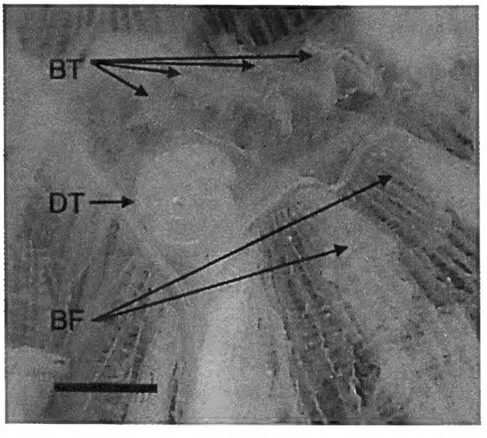

Fig. 8. Convoluted dorsal tubercle (DT), branchial tentacles (BT) and branchial folds (BF) of *Pyura discoveryi*. Photo J Pett. Scale bar 2 mm.

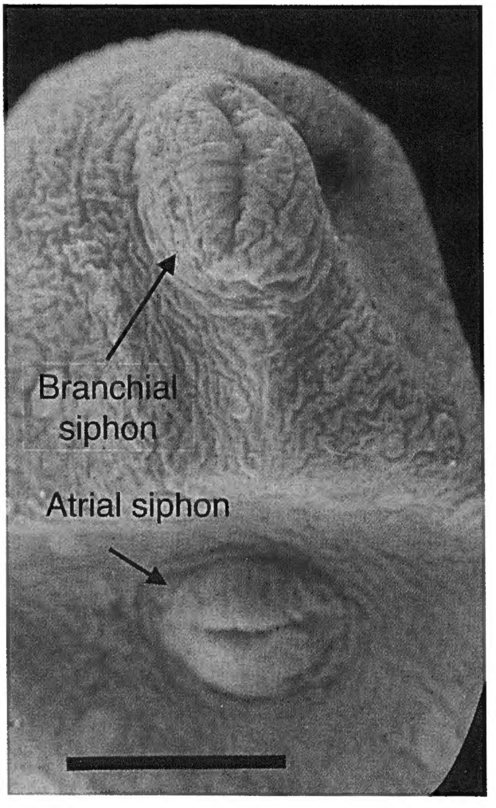

Fig. 10. Slit-like apertures of *Bathypera splendens* are distant and perpendicular to each other. Photo C Bathie. Scale bar 14 mm.

1969), said by Monniot *et al.* (2011) to form spirals (not observed in this specimen). The small dorsal tubercle, which to us resembled the number 9, accords more closely with the original description—a simple comma shape with a lengthways slit on the right side (Michaelsen 1904) (Fig. 11)—than those of later observers. Muscular fibres forming a criss-cross pattern across the body do not reach the ventral line (Monniot *et al.* 2011), rendering visible the elongated right gonad (Fig. 12). The gut loop occupies the ventral half of the left side (Monniot *et al.* 2011) (Fig. 13). The left gonad lying within the gut loop consists of a narrow tubular ovary overlaid by two rows of testis lobes (Kott 1969). Rows of endocarps are dorsal to the gut loop and the right gonad but limited to the ventral half of the body (Monniot *et al.* 2011). The stomach is folded. The inside of each siphon is lined with papillae arranged in curved lines converging at the aperture (Fig. 14). At 400 × magnification, we observed each papilla as a hemisphere of triangular spicules on a short pedestal (Fig. 15). The pimples noted on the outside are the same papillae arranged in horizontal rows of astonishing regularity. The presence of such spicules is diagnostic of

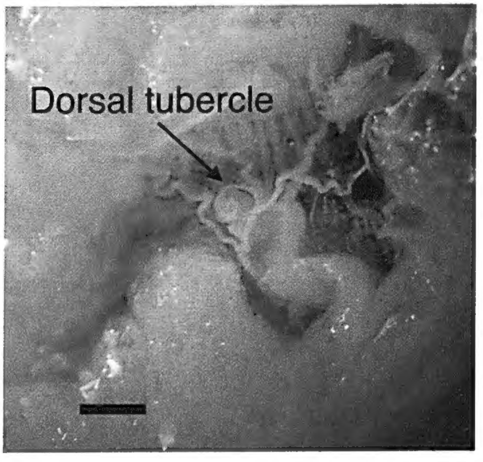

Fig. 11. Dorsal tubercle *Bathypera splendens*. Photo C Bathie. Scale bar 2 mm.

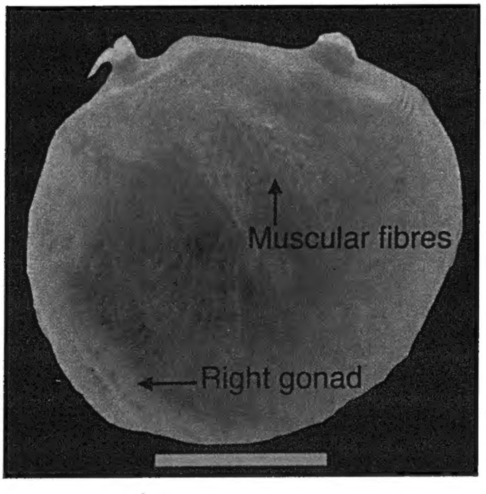

Fig. 12. Criss-cross muscular fibres and right gonad visible through the body. Photo C Bathie. Scale bar 25 mm.

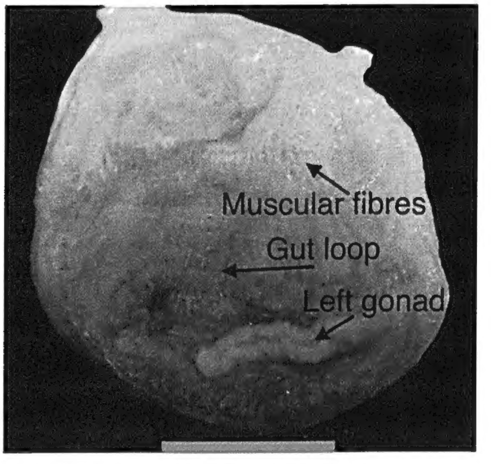

Fig. 13. Left gonad inside gut loop is visible through the body in the ventral half of left side *Bathypera splendens*. Photo C Bathie. Scale bar 25 mm.

Fig. 14. Internal papillae arranged in curved lines converge at the atrial aperture. Photo J Pett. Scale bar 2 mm.

Bathypera (Michaelsen, 1904). Monniot *et al.* (2011) concur that such 'stub-like' spicules, 'with a rounded base, upper side divided into spines of equal size' are characteristic of *Bathypera splendens,* and distinguish that species from the almost identical Antarctic *Bathypera hastaefera* Vinogradova, 1962, in which the spines are asymmetrical and few (Fig. 16).

Remarks

The solitary ascidian test may vary morphologically within as well as between species, and it is frequently necessary to dissect to identify definitively (Kott 1997), even when specimens have been observed *in situ,* in characteristic habitat. Preserved specimens are often pallid and grotesque versions of living animals. Nevertheless ascidians can usually be distinguished from other invertebrates by the presence and form of incurrent and excurrent siphons. The current specimens, however, had been shelved by external morphology with the Class Holothuroidea (sea cucumbers) and were excluded after dissection (P Mark O'Loughlin, pers. comm., 21 August 2017). The siphons of all three species were misleading—those of *Pyura discoveryi* in length, shape and orientation, and those of *Bathypera splendens* with barely visible slits instead of multilobed apertures. The larger *Cnemidocarpa pfefferi,* with barely discernible siphons, had been taken for another *Bathypera splendens,* and the smaller was a nondescript epibiont of *Pyura discoveryi.*

Cnemidocarpa pfefferi ***(Michaelsen, 1898)***

These specimens look more like dim sims than animals (Fig. 5). If, after the identification of terminal anterior siphons, *Cnemidocarpa* had been anticipated, the most likely upright candidate for NMV243197 would have been *Cnemidocarpa verrucosa* (Lesson, 1830). Observed on a wide range of substrates at shallow or bathyal depths and in a variety of shapes and colours (Brueggeman 1998), *C. verrucosa* is the most abundant and conspicuous of the genus, found in all Antarctic and sub-Antarctic waters, and the best-studied (Sahade *et al.* 2004). However, once the tunic was breached, the distinctive gonads of *Cnemidocarpa pfefferi* were visible through the body wall and conspicuous at incision.

Indentations in the ovarian branches hold the testis ducts, which instead of lengthening as the ovary extends, are pulled tighter across the extension, causing grooves and eventually forming the double branches through which the testis ducts reach the vas deferens on the mesial surface of the ovary (Kott 1969) (Fig. 7). The testis and ovary lie within a common membrane, characteristic of *Cnemidocarpa* (Millar 1960). The largest reported specimens of *Cnemidocarpa pfefferi,* at 55 mm high and 22 mm wide, are still those examined by Kott (1969) and found at depths up to 383 m. Slightly smaller specimens have been taken at

Fig. 15. *Bathypera splendens* hemisphere of triangular spicules on a short base. Sketch C Bathie. Scale bar 60 µm.

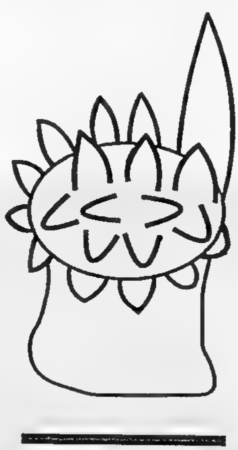

Fig. 16. Unequal spicules of *Bathypera hastaefera* after Monniot *et al.* (2011). Sketch C Bathie. Scale bar 60 µm.

770 m (Monniot *et al.* 2011). This species is widely distributed in Antarctic waters. The genus was originally *Styela* Fleming, 1822, and *S. pfefferi* Michaelsen, 1898, one of several species characterised by 'immense' development of ovarian tubes (Kott 1969), distinguished from *S. wandeli* (Sluiter 1911), which has unusually large testis lobes (Kott 1969).

Pyura discoveryi *(Herdman, 1910)*
Pyura discoveryi was originally assigned to the genus *Halocynthia*, and named for the ship Discovery, of the British National Antarctic Expedition 1901–1904 (Herdman 1910). *Pyura discoveryi* is widely distributed around Antarctica. In various habitats, from rocks at a depth of 200 m to aggregations in ooze at 700 m, individuals attach to the substrate and to each other by irregular surfaces (Millar 1960) and the thread-like processes we observed on the sides of the tunic (Monniot *et al.* 2011) (Fig. 3 A). Aggregation increases stability on soft sediments, desirable where currents are strong, and increases substrate available to other sessile invertebrates, including other ascidians. *Pyura discoveryi* has often been observed as an epibiont on *Pyura setosa* (Sluiter, 1905) (Tatián *et al.* 1998), and one of our specimens supported a tiny *Cnemidocarpa pfefferi.*

Although aggregated solitary ascidians do not interact with each other, proximity is advantageous, increasing the likelihood for fertilisation in fast currents that carry gametes away (Kott 1997). The non-feeding larvae, which develop rapidly, have been found to metamorphose faster in response to chemical signals in the water column from the same species, and to settle quickly around adults (Segelken-Voigt *et al.* 2016). This early life history of ascidians may account in part for the surprisingly patchy and sparse distribution of Antarctic ascidians, noted by Kott (1969) in the few images then available of ascidians *in situ*, and confirmed recently by studies employing photographic transects of the sea floor rather than the beam trawl (Segelken-Voigt *et al.* 2016). The latter is known to drag together individuals or small aggregations that may have been widely separated, on substrates that differ considerably, or to represent as unusual a species that was abundant nearby (Monniot *et al.* 2011). Photo transect methods, on the other hand, which depend on counting specimens in images, are known to underestimate abundances of invertebrates (Sahade *et al.* 1998). It would be less likely that the small *Cnemidocarpa pfefferi* attached to *Pyura discoveryi* would be identified.

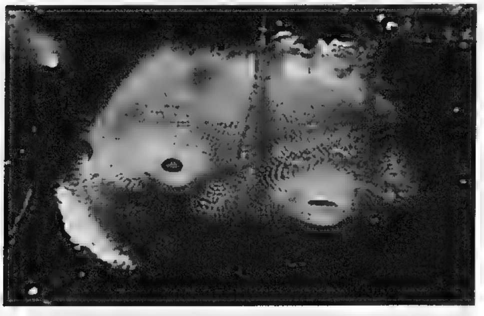

Fig. 17. *Bathypera feminalba.* Image courtesy Ocean Networks Canada.

Density of benthic filter-feeding invertebrate communities is indicative of abundant plankton in the water layer close to the bottom (Monniot *et al.* 2011). Melting of sea ice in summer causes high phytoplankton blooms that descend through the water column, forming a major food source (Segelken-Voigt *et al.* 2016). For sessile animals unable to collect food once it has fallen to sediment surfaces, another major resource is resuspended benthic material (Kowalke *et al.* 2001). Containing organic detritus, including benthic diatoms such as *Fragilariopsis kerguelensis* (O'Meara) Hustedt, 1952, abundant at Four Ladies Bank (Quilty 1997), sediment is disturbed by meltwater from the iceshelf, and in the shallow water, by drifting and grinding icebergs. However, loose sediment is also a threat to filter feeders; clogging of branchial apertures and the stigmata of the branchial sac can be fatal (Segelken-Voigt *et al.* 2016). Ascidians have few defences, the ability to squirt being the most obvious one. Circular muscles regulate the size of the siphonal apertures; contractions of the body muscles compress the body, forcing jets of water out from the siphons (Ruppert *et al.* 2003). Studies in western Antarctica have found that *Cnemidocarpa verrucosa* (and possibly *C. pfefferi*) can increase their rate of squirting. Ascidians whose habit is to lie flat on a side (e.g. phlebobranch *Ascidia challengeri* Herdman, 1882) survive

periods of turbulent sediment by reducing filtering efficiency (Torre *et al.* 2014). In some species, individuals benefit from a flexible stalk raising them above the turbulence (Segelken-Voigt *et al.* 2016). In *Pyura discoveryi*, a lengthened or heightened branchial siphon may be above or turned away by onrushing sediment (see Fig. 45 in Millar 1960), while the atrial siphon projects effluent above the sediment, minimising its own contribution to disturbance (Kott 1969). Some *P. discoveryi* individuals have siphons quadrangular in section, with deep grooves running along them, a feature apparently unique to this species (Herdman 1923). Other siphons narrow towards the apertures. In either case, compared with those of most solitary ascidians, the siphons are longer in proportion to the bodies even when retracted, and neither the lengths of the siphons relative to the bodies nor their orientations are consistent. Siphonal growth and orientation is a response to the environment (Kott 1997); usually the terminal branchial siphon faces the oncoming current and the dorsal atrial siphon points the other way. This is achieved by differential growth in the siphons in the optimal direction for the individual, some compensation for the inability to move towards potential food (Kott 1997), and we noted siphons pointing horizontally or downwards as well as straight upwards.

An individual *P. discoveryi* can look much like the holothurian *Ypsilothuria bitentaculata* (Ludwig, 1893), found at Ningaloo Reef off Western Australia (Byrne and O'Hara 2017). An even more convincing image, of a Mediterranean specimen of this echinoderm with oral and anal siphons, can be seen in Mecho *et al.* (2014). Somewhat paradoxically, fixed positions in preserved specimens of *P. discoveryi* can obscure the small range of movement crucial to sessile ascidians, which rapidly and vigorously contract in response to unwanted stimuli. The water of Prydz Bay constantly carries large inorganic particles of glacial origin, which must be filtered out before reaching the branchial sac (Kowalke *et al.* 2001). In addition to the feathery branched pyurid branchial tentacles, at the base of each siphon is a projecting membrane with a strong ring of muscle, considered by Kott to be a sphincter to close the aperture, and perhaps a safety mechanism in view of the length of the siphon (Kott 1969).

The most similar species to *Pyura discoveryi* is *Pyura haustor* (Stimpson 1864), once known only from the Arctic and proposed by Kott (1969) as an example of bipolarity. More recently, this species has been found from Alaska to California. *Pyura haustor* differs in having siphonal spines (Sanamyan and Sanamyan 2006).

Bathypera splendens ***Michaelsen, 1904***

A most remarkable and ornamental genus, according to Herdman (1923), living *Bathypera* are said to resemble antique beaded purses (Young and Vásquez 1995). Few have been observed *in situ*. From a manned submersible in Saanich Inlet, British Columbia, these animals appeared brilliantly white and delicate (Fig. 17). *Bathypera feminalba* Young and Vásquez, 1995 (named for the dive site locally called White Lady Rock), like *Bathypera hastaefera* Vinogradova, 1962, is separated from *Bathypera splendens* only by the shape of the spicules on the papillae (Young and Vásquez 1995).

Although the *Bathypera* test is thin, the magnesium calcite spicules (Lowenstam 1989) are rough to the touch (Millar 1960), and when siphons are retracted, form the barrier across the aperture. Lowenstam (1989) speculated that this may deter invertebrates known to live commensally with other ascidians; it was ineffective against the amphipod and polychaete inside our specimens. Young and Vásquez (1995) demonstrated in their study of juveniles that each spicule begins as a tiny round crystal on the margin of the tunic as the animal grows. They observed no *Bathypera* with epibionts of any kind, and noted that juveniles were found only around the base of adults, never on them. We investigated one of 16 circular (3 mm in diameter) white patches on the test of *B. splendens*. A raised thick border of spicules formed the circle, and within were sparse rows of broken spicules surrounded by detritus. Many spicules were missing, leaving behind circular depressions in the regular rows. This may represent unsuccessful predation—tunics of Antarctic *Bathypera* hold repellent chemical substances (Moles *et al.* 2015)—or senescence. The lifespan of solitary ascidians is not well documented; one to three years is frequently

suggested, and some Antarctic species with slower growth rates may exceed this. Flat species are said to live longer than erect ones such as *Bathypera* (Kowalke *et al.* 2001).

Bathyspera splendens, the first of the genus to be described, is eurybathic and found throughout Antarctica. It was initially assigned to the Molgulidae; curved stigmata of the branchial sac are not oriented longitudinally as in most pyurids. However, there is no renal sac characteristic of molgulids. Early observers may have taken endocarps for renal organs (Van Name 1945); the function of endocarps, however, is still not understood, although they may have some role in excretion (Kott 1985) or reproduction (Sahade *et al.* 2004; Kott 2005).

The other two *Bathypera* species are *B. ovoida* (Ritter, 1907), collected from the Pacific Ocean (at a depth of 184 m off Japan, and 3680 m off California) (Young and Vásquez 1995), and *Bathypera goreaui* Millar and Goodbody, 1974, known only from a reef near Discovery Bay, Jamaica (Millar and Goodbody 1974). These differ obviously from *B. splendens* and *B. feminalba* in that the siphonal apertures point the same way. Again the shape of the spicules on the papillae is characteristic; as is the number of branchial folds (Van Name 1945). Some past controversy can be attributed to deterioration of spicules when specimens had been preserved in unbuffered formalin (Lowenstam 1989). New, *Bathypera* species, or the expansion of known geographical distributions, may result from sampling of abyssal depths around the globe, and as scuba divers report from shallower water than has previously been sampled in the Antarctic (Schories *et al.* 2015).

Unlike *P. discoveryi* with its hair-like projections enabling it to anchor in silt, *B. splendens* attaches to the substrate by a smooth posterior surface patch. In Saanich Inlet, *B. feminalba* was dredged from shell rubble or stony bottoms, but never from soft sediments; likewise *B. goreaui. B. feminalba* was observed to be most abundant on vertical cliffs. Young and Vásquez (1995) concluded that *B. feminalba* thrives on hard surfaces where currents are gentle.

Trawls of Four Ladies Bank were likely to encounter thick sediment and strong currents (Harris *et al.* 1998). We note, however, that much of the sandy or muddy bottom investigated off Terre Adélie (eastern Antarctica) contained large angular pebbles, on which ascidians had settled (as they had on other sessile animals like sponges or tubeworms) (Monniot *et al.* 2011). Among unregistered ascidians from Prydz Bay (1991, 1993) awaiting investigation at Museums Victoria are several specimens we now judge to be *B. splendens*, along with numerous *P. discoveryi*—conditions suitable for both these species had persisted over several years.

Conclusion

Our task was to examine some marine invertebrates from Prydz Bay noted 'not holothurian'. We identified three species of solitary Stolidobranch ascidians, not previously recorded as present in Museums Victoria's survey collection: *Cnemidocarpa pfefferi, Pyura discoveryi* and *Bathypera splendens*. These species are poorly represented in Australian zoological online catalogues, and the records largely represent collections made in the 1930s; the few recent additions are from the 2008 CEAMARC survey. This may be attributed to the scale of the task of digitising records, but the absence of relevant literature indicates otherwise. Our investigation suggests that there are ascidians collected from Australian Antarctic Territory waiting to be examined.

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Notes on the Ascidian component of a Marine Benthos survey in Australian Antarctic Territory

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Abstract

Quantified abundance of ascidians (sea squirts) across different substrates in Australian Antarctic Territory is derived from Marine Benthos survey data, and the possible impact of climate-induced glacier retreat on ascidian assemblages is discussed. (*The Victorian Naturalist*, 136 (1), 2019, 16–20)

Introduction

The Marine Benthos Program on Voyage 5 (BRAD) 1996/97 by Research Survey Vessel *Aurora Australis* aimed to quantify the abundance and diversity of benthic macroinvertebrates on different sediment types in four areas of Prydz Bay (Bardsley 1997). Unlike previous projects that collected marine invertebrates as bycatch from other programs (Zeidler 2015), this investigation sampled benthic invertebrates directly, and produced the specimens discussed in the article 'Three Antarctic ascidians from Four Ladies Bank' (Bathie and Pett 2019). The distribution of ascidians across different substrates 21 years ago led us to consider the possible impact on ascidians of glacier retreat, which has been associated with more frequent ice scour events and increased rates of sedimentation (Sahade *et al.* 2015). Although ascidians have been proposed as sentinel species able to signal effects of global warming on benthic composition (Segelken-Voigt 2016), our investigation indicates that ascidians in Australian Antarctic Territory have received little attention so far.

Prydz Bay

Prydz Bay on the east coast of Antarctica is a deep embayment where the giant drainage system of Lambert Glacier ends at the Amery Ice Shelf (Fig. 1, Bathie and Pett 2019). Prydz Channel is a broad trough, 400–500 m deep and up to 100 km wide and was probably eroded by a fast-flowing ice stream passing seaward, now between Fram Bank and Four Ladies Bank (O'Brien *et al.* 2016). From a depth of 700 m in the Amery Depression, the sea floor rises gently to Four Ladies Bank, a shelf bank 100–200 m deep, the edge of which probably marks the outer limit of the East Antarctic Ice Sheet at the Last Glacial Maximum (Mackintosh *et al.* 2014). Most areas of Prydz Bay shallower than 690 m show iceberg ploughmarks (O'Brien *et al.* 1997), some relict and some that may have been freshly made by large modern icebergs (O'Brien *et al.* 2016). Much of the sea floor consists of fine mud and biosiliceous ooze (O'Brien *et al.* 2014).

Materials and Methods

Working in conjunction with the 21-day marine geophysical survey and sediment sampling program (Harris *et al.* 1998), zoologists and biologists from Museum of Victoria (now Museums Victoria) and Deakin University were allocated 48 hours for sampling the benthos of Prydz Bay (Bardsley 1997; Quilty 1997).

Four sites were sampled to examine the distribution of benthic macroinvertebrates on different sediment types: Fram Bank (67° 10' S, 70° 40' E, 290 m), Prydz Channel (67° 10' S, 72° 19' E, 550 m), Prydz Channel East (67° 10' S, 74° 30' E, 430 m), and Four Ladies Bank (67° 27' S, 76° 40' E, 320 m) (Bardsley 1997) (Fig. 1).

Five beam trawls were conducted at each site, deployed for up to 10 minutes per drag and towed at a speed of 1 to 1.5 knots, enabling calculation of the area trawled and hence the density of organisms (mass kg/m^2) (Bardsley 1997). The metal trawl frame was 3 m long and 0.5 m high with runners at either end. The leading edge of the 8 m cone-shaped net (30 mm mesh) attached to a weighed chain formed a ground rope that curved back behind the top of the net to the beam so that mobile animals disturbed by the ground rope could not escape upwards.

The first trawls took place on 22 February 1997 in Prydz Channel, the last one failing when wire wrapped around the trawl frame. Deteriorating weather then stopped the project for a few days but the Voyage Leader recorded that morale was very high after productive hauls (Quilty 1997). Trawling resumed on 4 March on the northern face of Fram Bank, followed by a revisit to Prydz Channel, that was fruitful despite the net being badly torn. A team worked overnight to repair it before the last trawls at 320 m on the western flank of Four Ladies Bank (Quilty 1997). Collected material was sorted to Class or Order, the mass and number of individual specimens recorded for each taxon. All

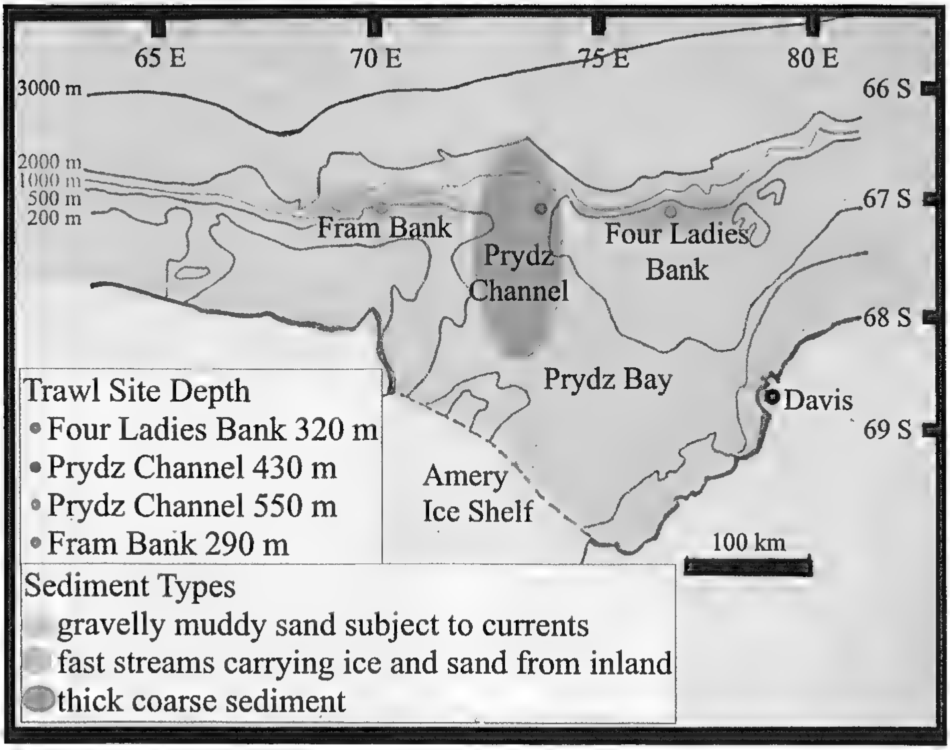

Fig. 1. Trawl sites and sediment types of the 1997 Marine Benthos Program (Quilty 1997). After Harris *et al.* (1998) and O'Brien *et al.* (2016).

material was to be lodged and curated at the Museum of Victoria (Bardsley 1997).

Results

Successful hauls varied between 57 and 200 kg of material (Bardsley 1997). Prydz Channel sites (400–500 m) subject to streams carrying gravel and sand from inland (Harris *et al.* 1998) and carrying meltwater from the ice shelf (Williams *et al.* 2016), were dominated by Porifera (sponges), Holothuroidea (sea cucumbers) and Pennatulacea (sea pens). Only 5% of the total mass of Ascidiacea (sea squirts) came from the channel. The highest biomass on the thick but coarse sediment on the northern face of Fram Bank (300 m) (Harris *et al.* 1998) was again Porifera, but followed by Ascidiacea (72% of Ascidian mass). Trawls at Four Ladies Bank, in gravelly muddy sand (Harris *et al.* 1998) subject to ocean currents entering the bay, also produced an abundance of sponges, but there were fewer sessile sea squirts than mobile sea cucumbers. Four Ladies Bank contributed 23% (10 kg) of the total mass of Ascidiacea (Fig. 2).

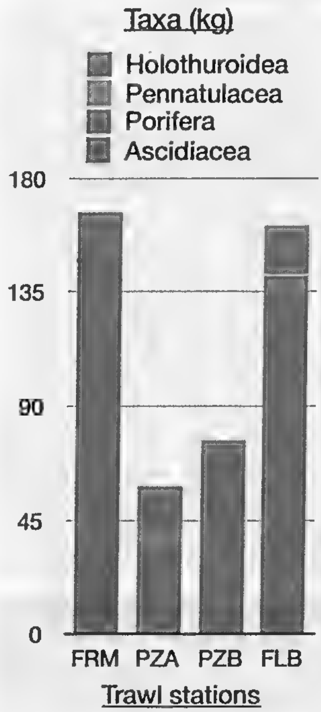

Fig. 2. Dominant taxa (kg) recorded for trawl stations (Bardsley 1997). FRM: Fram Bank, PZA: Prydz Channel A, PZB: Prydz Channel B, FLB: Four Ladies Bank.

Antarctic ascidians and the effects of climate change

The authors have alluded elsewhere to material from previous Prydz Bay surveys (1991, 1993) awaiting examination at Museums Victoria (Bathie and Pett 2019). After viewing the collection, we judge it to include several specimens of two species we discussed: *Pyura discoveryi* (Herdman, 1910), often found anchored in sediment (Herdman 1923), and *Bathypera splendens* Michaelsen, 1904, which probably prefers vertical or sloping flat surfaces subject to currents inhibiting the buildup of sediment (Young and Vásquez 1995). Whereas our small sample included *Cnemidocarpa pfefferi* (Michaelsen, 1898), the unregistered material appears to be dominated by *C. verrucosa* (Lesson, 1830), said to be the most abundant and conspicuous *Cnemidocarpa* in Antarctic waters (Brueggeman 1998), and known to survive periods of turbulent sediment by increasing the rate of squirting (by which it repels matter likely to block branchial apertures) (Torre *et al.* 2014).

The authors have no information about the relative abundances of these species, but note that populations can change rapidly. Sea ice that melts in summer is proposed as a proxy for availability of food for ascidians in the Antarctic (Segelken-Voigt *et al.* 2016; Bathie and Pett 2019), but drifting icebergs of glacial origin can have a devastating effect on sessile communities. Ice scour, which can modify the substrate while seasonally removing the bottom fauna of large areas (Tatián *et al.* 1998), has been studied intensively as a key structural force shaping benthic communities (Torre *et al.* 2017). Ascidians with high growth rates are known to colonise quickly after a change to the substrate (Kowalke *et al.* 2001), and one species may be rapidly replaced by another in a complex interplay of limiting factors. New silt barriers can prevent larval dispersal, or directly kill juveniles (Young and Chia 1984). Sediment dwellers are less likely to re-establish on newly bare rocks. A reduction in light levels (caused by suddenly proliferating algae) deterring larval settlement, or competition from other sessile invertebrates

(like the sponges dominating assemblages in Prydz Bay), could produce local conditions conducive to the spread of *C. pfefferi* where *C. verrucosa* previously had been dominant, or vice versa. It is evident that in conditions of high sedimentation and frequent ice scour, abundant, diverse and changing benthic communities, including ascidians, have flourished in Antarctica (Sahade *et al.* 2015). This fast response to environmental modification makes ascidians potential indicators of environmental change (Segelken-Voigt 2016).

Recently, attention has turned to the effects of climate change. In western Antarctica, Sahade *et al.* (2015) reported major shifts in assemblage structure attributable to increased sedimentation rates associated with glacier retreat. Communities in which the dominant filter-feeders had been ascidians in 1998, were dominated by sponges and seapens by 2010—evidence that sediment-tolerant assemblages had reached a critical threshold of sediment sensitivity, after which the whole ecosystem had shifted to an alternative equilibrium (Sahade *et al.* 2015)—although this change was observed in habitat closest to the glacier, rather than on outer shelf banks. Also, at Potter Cove, it was hypothesised that in a location newly exposed by glacier retreat, known ascidian pioneer species such as *Molgula pedunculata* (Herdman, 1881) would dominate; in fact, the most abundant was *C. verrucosa* (Lagger *et al.* 2017) with its ability to increase the rate of squirting. It is likely that *M. pedunculata*, commonly observed with a stalk holding it above the sediment of the substrate (Torre *et al.* 2014), has been disadvantaged in a changing environment. In laboratory conditions of increasing sedimentation, Torre *et al.* (2014) measured no changes in filtration or ingestion which might mitigate the risk of suffocation.

It remains to be seen whether the glacial melt observed in western Antarctica, with increased rates of sedimentation and more frequent episodes of ice scour (Torre *et al.* 2017) will also be observed in Australian Antarctic Territory. The Collaborative East Antarctic Marine Census (CEAMARC) (2007–2008) was a multinational effort to survey the waters north of Terre Adélie, and George V Land with the intention of producing a benchmark against which future changes to marine life in eastern Antarctica can be studied (Terre Adélie is the French claim between segments of Australian Antarctic Territory) (Fig. 1, Bathie and Pett 2019). After RSV *Aurora Australis* sampled benthic communities of the continental shelf and slope down to 2000 m (Hosie *et al.* 2011), a French team produced the report on ascidians off Terre Adélie (Monniot *et al.* 2011). There, *M. pedunculata* (15% of solitary ascidians) had outnumbered the genus *Cnemidocarpa* (6.5%, which included five specimens of *C. pfefferi* and ten of *C. verrucosa*). *Pyura discoveryi* also represented 15% of solitary ascidians, and the genus *Bathypera*, 8.1% (Fig. 3).

To date, this is the only information available to us for future comparisons of the ascidian component of eastern Antarctic benthic assemblages. As was anticipated at the time of the CEAMARC survey, the Mertz Glacier Tongue of George V Land broke off in February 2010 (Hosie *et al.* 2011). The effects of the expected ice scouring of the sea floor, along with changes to sedimentation and the sea ice regime, are yet to be investigated directly by sampling of benthic invertebrates (Jansen *et al.* 2018).

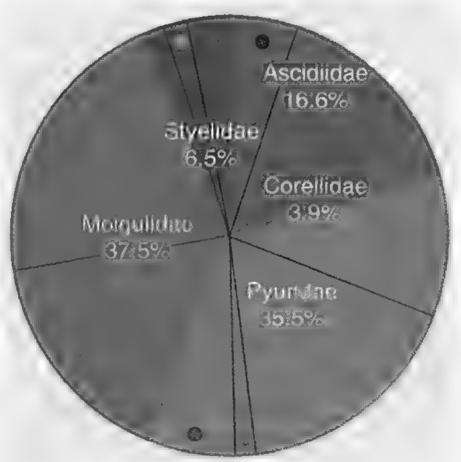

Fig. 3. Each family and species as a percentage of total solitary ascidians collected in east Antarctica by CEAMARC (Monniot *et al.* 2011). Species Key: *Molgula pedunculata* 15%, green dot; *Cnemidocarpa pfeffferi* 1.6%, yellow dot; *Cnemidocarpa verrucosa* 3.2%, blue dot; *Ascidia challengeri* 5.2%, black dot; *Pyura discoveryi* 15%, red dot; *Bathypera splendens* 6.5%, pink dot; *Bathypera hastaefera* 1.6%, grey dot.

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The Tasmanian records of the Short Spider-orchid *Caladenia brachyscapa* G.W. Carr and of two closely related specimens

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Abstract
Two records of the Short Spider-orchid *Caladenia brachyscapa* G.W. Carr, and two closely related specimens, are discussed. The latter two were found on Clarke Island and Cape Barren Island, in the Furneaux Group, Tasmania, and their habitats are described. The taxon's status of 'endangered' under the *Tasmanian Threatened Species Protection Act 1995* is discussed, as is its premature assessment as presumed extinct or possibly extinct in Victoria. (*The Victorian Naturalist*, **136** (1), 2019, 21–24)

Key words: Short Spider-orchid *Caladenia brachyscapa*, endangered Tasmanian plant, Cape Barren Island, Clarke Island, critically endangered Victorian plant

Introduction

When GW Carr described the Short Spider-orchid *Caladenia brachyscapa* as a Victorian endemic, he assessed it as 'possibly extinct' (1988, 442). He was unaware that it had been collected in Tasmania on Clarke Island, in 1979. Next, the species was taken on Cape Barren Island, which is just north of Clarke Island, in 2007. *Caladenia* sp. aff. *brachyscapa* has been found at Clarke Island in 1982 and on Cape Barren Island in 2007. The Tasmanian sites are described. The taxon's status of 'endangered', under the *Tasmanian Threatened Species Protection Act 1995*, is discussed. So is its premature assessment as presumed extinct, or possibly extinct, in Victoria.

Clarke Island

Western Robin Hill

The western part of Clarke Island's northern massif is granite largely overlain by later sand. A track ran from the west to the saddle between Robin Hill, the southern part of the granite, and the main mudstone area known as Steep Hill. This sandy slope has been burnt many times since grazing began on the island in 1846, reducing the dominant Tasmanian Blue Gum *Eucalyptus globulus* subsp. *globulus* to scattered, stunted patches amongst often dense scrub. Two plants of a Spider-orchid were collected by the author at the northern edge of the track on 7 November 1979. Jones *et al.* (1994) identified them as the Short Spider-orchid and illustrated one of the plants collected. There were no local Blue Gums and the taller shrubs of the site were Prickly Moses *Acacia verticillata*, Smooth Teatree *Leptospermum laevigatum*, Manuka *Leptospermum scoparium*, Paperbark *Melaleuca ericifolia*, South-eastern Broom-heath *Monotoca elliptica*, and Coast Cherry *Exocarpus syrticola*. The smaller shrubs were Sticky Boronia *Boronia anemonifolia* var. *variabilis*, Golden Pea *Pultenaea gunnii* and Cranberry Heath *Astroloma humifusum*. The main ground cover was the Bare Twig-rush *Baumea juncea*. Also present were Errienallum *Drosera auriculata*, Potato Vine *Billardiera mutabilis* and the Small Bearded Greenhood *Pterostylis tasmanica*.

The vegetation of the slope varied considerably. The extra shrubs beside the track, at 50 m west of the Spider-orchid's site, were Prickly Beauty *Pultenaea juniperina*, Shrub Everlasting *Ozothamnus ferrugineus*, Lance Currant-bush *Leucopogon affinis*, Honeysuckle *Banksia marginata* and Twiggy Daisy-bush *Olearia ramulosa*.

Further searches were done in November 1982 but the Short Spider-orchid was not noticed on the western and south-eastern slopes of Robin Hill, nor on the northern slope of Bullock Hill, the island's low north-western rise.

South-east of Sandy Lagoon

The sand of the western slope of Robin Hill continues to the east and is joined, before Sandy Lagoon, by sand that came in over the northern slopes of Steep Hill. It forms an uneven flat in the vicinity of Sandy Lagoon and there are swamps and smaller lagoons in swales and hollows. In late 1982, very little of the flat carried

mature vegetation. Instead there were several ages of vegetation as a result of graziers' burning off. Two plants of an orchid approaching the Short Spider-orchid were found amongst regrowth shrubs on a sandy bank near the north-western corner of a narrow, mapped lagoon. Whip-stick Teatree *Leptospermum glaucescens*, Manuka *Leptospermum scoparium*, Native Willow *Acacia mucronata*, Scented Paperbark *Melaleuca squarrosa* and Honeysuckle *Banksia marginata* would become the dominant species. The smaller shrubs were the Spreading Wattle *Acacia genistifolia*, Golden Pea *Aotus ericoides*, Mountain Milkwort *Comesperma retusum*, Sticky Boronia *Boronia anemonifolia* var. *variabilis*, Prickly Geebung *Persoonia juniperina*, Pink Swamp-heath *Sprengelia incarnata* and Smooth Parrot-pea *Dillwynia glaberrima*. Also here were Scrambling Coral-fern *Gleichenia circinata*, Bare Twig-rush *Baumea juncea*, Love Creeper *Comesperma volubile* and leaves of the orchid genera *Acianthus* and *Corybas*.

Cape Barren Island

Near Ariel Gully

Mount Munro is the summit of Cape Barren Island and Big Hill is its north-western knoll. Ariel Gully drains the latter's western side and it was all burnt on 24 October 2006. The first record was made on 29 September 2007 in the shallow gully of an unnamed minor tributary of Ariel Gully. Blue Gum *Eucalyptus globulus* subsp. *globulus* and Smithton Peppermint *Eucalyptus nitida* formed the dominant layer. Drooping Sheoak *Allocasuarina verticillata* was the understorey when the site was burnt in 2006. These shrubs have tillered to a cover of about 10%. About 80% of the c. 15° gravelly slope derived from granite is bare. Tall Cutting-rush *Lepidosperma elatius* (regrown to a c.15% cover), Common bracken *Pteridium esculentum*, Everlasting *Argentipallium dealbatum* and Errienallum form the sparse lower cover. There were 14 plants of a Spider-orchid in about 25 m^2. Several of them grew in the runnel of the seasonal stream. The specimen, which seemed to the author to be a mixture of several species—including the Short Spider-orchid—was determined at the Australian National Herbarium by Dr Mark Clements as *Caladenia* sp. aff. *brachyscapa* (Jo Palmer, pers. comm., 22 November 2012). Dr Clements has since decided that the specimen matches the description of the Short Spider-orchid (Jo Palmer, pers. comm., 20 February 2018). This makes it the second Tasmanian specimen of the taxon.

Gully of Big Hill Run

Big Hill Run rises on the western slope of Mount Munro and flows northward to the sea. The middle part of its gully is steep-sided and it was all burnt on 24 October 2006. The site of a patch of Spider-orchids was stony with about 15% granite. The dominant layer of Blue Gum and Smithton Peppermint has been opened by several fires. The site had, when burnt in 2006, a main understorey of Drooping Sheoak and Spreading Wattle. There was also one Needlewood *Hakea decurrens* var. *platytaenia*. The lower shrubs were Dwarf Cherry *Exocarpos strictus* and Shrubby Velvet-bush *Lasiopetalum macrophyllum*. The other species now are Tall Cutting-rush, Sand-hill Cutting-rush *Lepidosperma concavum*, Coarse Raspwort *Gonocarpus teucrioides*, Variable Stinkwood *Opercularia varia*, Mayfly Orchid *Acianthus caudatus*, Potato Vine and a single leaf of a Sun-orchid *Thelymitra* sp. Three of the 15 spider-orchid plants of the locality were collected. Two were Tailed Spider-orchids *Caladenia caudata* and the other a Spider-orchid *Caladenia* sp. aff. *brachyscapa*. The identity of the remaining plants is not known.

The Victorian status of the Short Spider-orchid

Carr (1988, 442) noted that '*Caladenia brachyscapa*, apparently a narrow [Victorian] endemic, is possibly extinct.' According to Backhouse and Jeanes (1995, 57), the species is known 'with certainty only from the type locality and now presumed extinct there, having been collected last in 1959.' Jeanes and Backhouse (2006, 48) repeated that the orchid is 'Presumed extinct in Victoria, where not seen since 1959.' However the specimen collected in south-western Victoria in 1992 is held at the Australian National Herbarium under the name of *Caladenia brachyscapa* (CBG9702469). This specimen contradicts the assessments of the species as possibly or presumed extinct in Victoria.

The identity of the Short Spider-orchid

Backhouse and Jeanes (1996:57) asserted that the species was 'Apparently related to both *Caladenia patersonii* and *Caladenia reticulata*... Now considered to be most closely related to *Caladenia caudata* from Tasmania, due to the structure of the osmophores.' By contrast Dr Mark Clements, of the Australian National Herbarium, considered that '*C. reticulata, C. australis* and *C. brachyscapa* are all extremely close if not the same taxon and work is currently underway to decide what the correct name should be' (Jo Palmer, pers. comm., 22 November 2012). Jeffrey Jeanes (13 December 1995) assessed the author's specimen of 1982 from Clarke Island as 'Approaching *Caladenia brachyscapa* G.W. Carr but marginal labellum calli longer and leaf smaller and narrower.' David Jones confirmed this assessment on 20 January 1986. These details come from a determinavit slip lodged with the specimen at the National Herbarium of Victoria. Had the first Tasmanian specimen close to the Short Spider-orchid been available when the species was described, it seems likely that the description would have been broadened somewhat from the features of the limited number of plants drawn on by Carr in 1988.

The current note is based on the assumption that the Short Spider-orchid is a distinct species and that the two Tasmanian specimens represent the taxon.

Discussion

The Victorian habitats of the Short Spider-orchid differ from the Tasmanian ones. Jeanes and Backhouse (2006: 48) noted that the species is 'Apparently restricted to a small area east of Warrnambool, where it grew in Messmate Stringybark (*Eucalyptus obliqua*) lowland forest, on grey sandy loam.' The final Victorian record, of November 1992, by Gellibrand River Road, occurred in 'Heath.' There are no other details.

It is possible, in the field, to distinguish Spider-orchid leaves found on the three main Furneaux Group islands from those of the Pink Fairies *Caladenia latifolia* and the Hare's Ears *Leptoceras menziesii*. On Cape Barren Island, in late 2007, there were flowering plants at all but one of the sites of Spider-orchid leaves. The flowerless site was at an altitude of about 270 m and this is close to the elevations of the two highest sites of the Mount Munro massif, both of which carried the Green-comb Spider-orchid *Caladenia dilatata* (Whinray 2012). So its leaves were likely to have been those of the same species.

By contrast, at Clarke Island in 1979 and 1982 there were seven sites with flowering Spider-orchids and five others that lacked any flowers. As Spider-orchids could not be determined at the latter localities, the flora is not known fully. Just the northern slopes of Bullock Hill, with granite outcrops, were inspected. Only a small part, less than 2% of the northern strip, formed from aeolian sand, was visited. Green Hill Gully was checked from the often-burnt tussock-grass of its head down to its mouth. It is a very unusual area with the western slope to the bed all sand from ancient dunes blown in from the west and its eastern slope weathered from granite. No Spider-orchid leaves were noticed in the gully or on the crest southwards from Green Hill to the tussocks of South Head. If Bullock Hill and the northern sandy areas could be searched thoroughly, especially after they were burnt by a major bushfire, the range of the five Spider-orchid species recorded for the island could be better ascertained.

The status of the Short Spider-orchid

The Victorian site where the Short spider-orchid was first collected has been cleared and the species has been found just once since then, in 1992. So it is inappropriate for it still to be assessed as 'possibly extinct' or 'extinct' in that State. There, it might be classed more appropriately as 'critically endangered'. The two Tasmanian sites of the taxon are unlikely ever to be cleared. As well, the species may occur at some of the Clarke Island sites where only Spider-orchid leaves were found in 1979 and 1982. The taxon is scheduled, under the Tasmanian *Threatened Species Protection Act 1995*, as endangered. The total number of plants at the two Tasmanian sites was just 19. It is not known whether any of the other 12 plants of the locality in Big Hill Run's gully were Short Spider-orchids rather than Tailed Spider-orchids. It could be appropriate to add the classification 'critically endangered' to the Tasmanian *Threatened Species Protection Act 1995*. If so, this more serious category would be suitable for the Short Spider-orchid.

The specimens

Caladenia brachyscapa G.W. Carr, *J.S. Whinray C2390*, 7.xi.1979, Robin Hill, Clarke Island, CANB 522013; approaching *Caladenia brachyscapa* G.W. Carr, *J.S. Whinray s.n.* 5.xi.1982, near Sandy Lagoon, Clarke Island, MEL 2380340; *Caladenia brachyscapa*, *J.S. Whinray 13,159*, 27.ix.2007, western slope of Big Hill, Cape Barren Island, CANB 834066; *Caladenia* sp. aff. *brachyscapa J.S. Whinray 13,172A*, 4.x.2007, eastern side of Big Hill Run's gully, CANB 499452; *Caladenia brachyscapa* G.W. Carr, *P. Barnett DLJ 10602*, 11.xi.1992, by Gellibrand River Road, 7–8 km south of Carlisle River, Victoria, CBG9702469.

Acknowledgements

The 1979 visit to Clarke Island was made possible by the generous loan of GWG Goode's small boat. Jeffrey Jeanes, of MEL, determined the specimen of 1982 from Clarke Island as close to *Caladenia brachyscapa*. David Jones, of CANB, confirmed Jeanes' assessment of that specimen. Jill Thurlow of the library at MEL supplied several very useful photocopies. Catherine Gallagher, also of MEL, provided prints of labels of orchid specimens from Clarke Island. Jo Palmer answered questions about specimens held at CANB. In December 2005 Sue Summers, of the Cape Barren Island Aboriginal Association, kindly arranged for continued access after much of the island became Aboriginal Land earlier that year.

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Some records of the lichen genus *Caloplaca*, (Teloschistaceae), for Banks and eastern Bass Straits

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Abstract

Specimens of the lichen genus *Caloplaca* have been collected right across Banks and eastern Bass Straits, from the Hogans Group by the Victoria/Tasmania border, down to Swan Island just off the north-eastern corner of the Tasmanian mainland. Three hundred and thirty-three of the 432 collections, from 52 islands and reefs, have been determined. They include 45 species. Five taxa were described using local specimens as the holotypes. A table of the species and islands is presented.

(*The Victorian Naturalist*, **136** (1), 2019, 24–28)

Key words: Lichen, *Caloplaca*, Teloschistaceae, Banks Strait and eastern Bass Strait, Tasmania

Introduction

The red *Caloplaca* lichens are a distinctive feature of the granite coasts of Wilsons Promontory, the islands of Banks and eastern Bass Straits, and parts of the east coast of the Tasmanian mainland. Some of the most impressive coastal scenery of the eastern islands is due to the brilliantly coloured, stain-like coating of the *Calaplaca* on the stone (Fig. 1). The most spectacular spot is a south-western inlet of Hogans Island where salt spray allows the *Caloplaca* to

grow to at least 40 m on the granite cliffs and a huge tor. By contrast, the limited salt spray lets it form just a narrow level band on the sheltered granite at the western end of Prickly Bottom Bay on Cape Barren Island. The other habit of *Caloplaca* is a pronounced thallus (fabric) that can, when wet, be removed from the stone by using the very sharp tip of a pen knife. Some of the latter species are close in appearance to those in the genera *Xanthoria* and *Jackelixia*. A few taxa grow further inland on stone and on shrubs.

This contribution presents records of *Caloplaca* collected from 52 islands and reefs across Banks and eastern Bass Straits from the Hogans Group near the Victorian/Tasmanian border down to Swan Island just off the north-eastern tip of the Tasmanian mainland. Forty-five species were identified from 333 specimens. The remaining 99 specimens have yet to be determined.

The most frequently collected species of the eastern islands are *Caloplaca gallowayi* (56 specimens from 20 islands), *C. jackelixii* (49 specimens from 23 islands), *C. whinrayi* (44 specimens from 29 islands), *C. marina* (23 specimens from 14 islands), *C. mccarthii* (22 specimens from nine islands), and *C. sublobulata* (22 specimens from 16 islands). All of the author's specimens were donated to the National Herbarium of Victoria at South Yarra. The records of all but one of the species given in the Appendix are based on specimens. The exception is *C. jerramungapensis*, which is on the same piece of limestone as the type specimen of *C. johnwhinrayi*.

Fig. 1. *Caloplaca* on rocks of south-west coast of Hogans Island, Bass Strait.

Barilla *Atriplex cinerea* is a host that was seldom collected. While there are scattered bushes on many islands, large areas of the shrub are found on a limited number of places. These are Little Chalky, Rum, Outer Pasco, Chappelle, Craggy and South West Islands. The latter two are remote. A dead shrub from Mile Island yielded *C. subluteoalba*, the sole local collection of the taxon. Only one of the major occurrences of the shrub was sampled and it yielded, at Little Chalky, the sole record, and type specimen, of *Jackelixia whinrayi*.

Unnamed specimens

Ninety-nine specimens of *Caloplaca* from thirty-one islands have not yet been determined. In some cases, they are the only collections of the genus from an island. The unnamed specimens are marked in the final row of the table of the genus. Two omissions are particularly disappointing. The first is specimens from South West Island in the Kents Group. When the author contacted Frank Goold, who ran the stores and post from Port Welshpool to the lightkeepers at nearby Deal Island for more than 20 years, he replied that 'The chances of landing a dinghy & keeping it with you [on the island] is I think impossible.' (Frank Goold, pers. comm., 15 September 1971). However the author landed twice single-handed, using a small aluminium dinghy, on successive days in December 1987. Launching the dinghy at the end of the second visit was very difficult. The second sample was a single collection from Pyramid Rock, well to the north-west of Flinders Island. It rises sheer from the sea to about 72 metres and the author was able to land just once in three visits. The rock is so exposed that no *Caloplaca* can be seen from the sea. The genus occurs at a spot about 50 metres above the sea.

The local type specimens

The type specimens are given in the order of collection.

Caloplaca feuereri was collected from granite on Little Island, in the Furneaux Group, on 19 May 1966.

Caloplaca johnwhinrayi was on small pieces of limestone on a bank, a former lime sand dune, behind the southern beach of the Inner Sisters Island on 15 December 1966.

Caloplaca craggyensis is endemic to Craggy Island, which is mainly a tourmaline-rich aplite dyke. It was collected in 1972 from the major stone of the island.

Caloplaca cliffwetmorei was found on a huge old Boobyalla *Acacia longifolia* var. *sophorae* at the head of the western end of Yellow Beach on Flinders Island on 8 July 1978. This tree has since died.

Caloplaca jackelixii was taken from dolerite on Cygnet Island, near Swan Island off the north-eastern corner of the Tasmanian mainland. The author reached the islet from Whitemark on Flinders Island, using a borrowed 4·2 metre boat, in April 1980.

Discussion

When the author's collecting began in 1966, only a few specimens in the genus *Caloplaca* had been collected from the islands of Banks and eastern Bass Straits. His work has raised the total number of *Caloplaca* species now recognised to 45. It remains to be seen whether the area is richer in species than other parts of the Australian coast. It could merely turn out to be only apparent when, or if, other parts of the coast are collected as intensively.

Some species of *Caloplaca* appear to be very uncommon on the eastern islands, as 16 of the 333 named specimens were collected just once. This apparent rarity may merely be the result of the rather random collecting, which has been comprehensive in very few spots. The author's first two major stays at the Kent Group in late 1970 and 1971 resulted in 546 specimens being collected, in a wide range of genera from four of the islands. These included 63 specimens of *Caloplaca*. Fifty-three of these have been determined and yielded 17 species.

While most of the lichen species of Little Dog Island, in the Furneaux Group, have been collected, the 57 specimens gathered between 1966 and 2018 do not include any *Caloplaca* samples. No stain-like species of *Calaplaca* occur on Little Island off Killiecrankie Bay, and its widespread taxa are ones with thalli that can be lifted from the stone, namely *C. feuereri* and *C. whinrayi*.

The author can offer some suggestions to anybody thinking of completing the survey of *Caloplaca* species of Banks and eastern Bass Straits. An obvious point would be that his 99 unnamed specimens should be determined in order to finish the work done to date. Then a list of each of his specimens would need to be compiled in order to avoid re-collecting at sites sampled already. It is likely that a key will appear in the proposed treatment of the genus in the *Flora of Australia*. Would it be practicable to work through an extensive key in the field before each sample was taken? It would not if the key required chemical testing.

When the author's work was done, there was a variety of fairly cheap ways, including a borrowed boat, to reach the eastern islands. Now transport would have to be by charter boat and that currently costs $2000 a day. Given this, it is doubtful that the expense of a further survey could be justified. Instead a potential collector going to a particular eastern island could get a list of all of its lichen specimens from the National Herbarium of Victoria and try to fill the gaps in it. The author will continue doing this as occasional visits can be made to islands near Flinders Island.

Acknowledgements

Sergiy Ya Kondratyuk determined the 333 *Caloplaca* specimens at the M.H. Kholodny Institute in Kiev, Ukraine. Catherine Gallagher, of the National Herbarium of Victoria, supplied several lists of the author's lichen specimens. The author used the small boat, lent by GWG Goode, when travelling some six thousand nautical miles for botanical collecting in the Furneaux Group and Little Swan and Cygnet. Maureen Christie was very helpful between 1967 and 1972.

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Appendix: A table of *Caloplaca* species for islands of Banks and eastern Bass Straits. IAO Reef: Inner Apple Orchard Reef; OAO Reef: Outer Apple Orchard Reef.

Species	Hogans	Long Islet	Dover	Erith	Deal	South West	North East	The Stacks	Pyramid Rock	Outer Sisters	Inner Sisters	Sentinel	Little	Inner Pasco	Middle Pasco	Outer Pasco	Babel	Cat
C. archerii								x										
C. bartlettii																		
C. beaugleholei					x													
C. bermaguiana																		
C. cerinelloides											x							
C. cinnabarina					x		x											
C. citrina												x						
C. clazkesensis																		
C. cliffwetmorei					x												x	
C. conranii							x											
C. craggyensis								x										
C. cranfieldii				x														
C. cribosa	x		x				x										x	
C. eos																		
C. erythrosticta		x										x						
C. feuereri			x					x					x					
C. flavocitrina				x	x						x							
C. gallowayi			x	x	x					x	x						x	
C. gyalectoides																		
C. haematommona								x										
C. jackelixii	x	x	x	x	x		x	x				x				x	x	
C. jerramungapensis											x							
C. johanmuelleri																		
C. johnwhinrayi											x							
C. kaernefeltii																		
C. kantvilassii				x	x						x							
C. kilcundaensis																		
C. lateritia																		

Species	Storehouse	Prime Seal	Low Islet	Flinders	Chalky	Mile	Isabella	Little Chalky	Green	Kangaroo	Chappelle	Badger	Little Goose	Goose	Isabella Reef	Beagle Reef	Long	Woody
C. archerii																		
C. bartlettii				x														
C. beaugleholei				x								x					x	
C. bermaguiana																		x
C. cerinelloides				x														
C. cinnabarina																		
C. citrina																		
C. clazkesensis																		
C. cliffwetmorei				x														
C. conranii							x											
C. craggyensis																		
C. cranfieldii																		
C. cribosa										x					x			
C. eos																		
C. erythrosticta																		
C. feuereri		x																
C. flavocitrina																		
C. gallowayi				x			x			x	x	x					x	x
C. gyalectoides																		
C. haematommona																		
C. jackelixii				x		x				x	x		x			x		
C. jerramungapensis																		
C. johanmuelleri																		
C. johnwhinrayi		x																
C. kaernefeltii		x		x														
C. kantvilassii				x						x	x							
C. kilcundaensis		x		x														
C. lateritia																		

Species	Little Green	Big Dog	OAO Reef	IAO Reef	Doughboy	Cape Barren	Battery	Night	Gull	Preservation	Rum	Sea Lion	Penguin	Clarke	Spike	Cygnet	Little Swan	Swan
C. archerii																		
C. bartlettii																		
C. beaugleholei												x						
C. bermaguiana														x				
C. cerinelloides																		
C. cinnabarina																		
C. citrina																		
C. clazkesensis														x				
C. cliffwetmorei	x											x						
C. conranii					x	x												
C. craggyensis																		
C. cranfieldii																		
C. cribosa																		
C. eos																	x	
C. erythrosticta																		
C. feuereri																		
C. flavocitrina																		
C. gallowayi		x				x						x		x			x	x
C. gyalectoides										x								
C. haematommona																		
C. jackelixii					x		x	x	x					x		x		x
C. jerramungapensis																		
C. johanmuelleri												x						
C. johnwhinrayi																		
C. kaernefeltii																		
C. kantvilassii																		
C. kilcundaensis						x												
C. lateritia																		x

Appendix cont.

Species	Hogans	Long Islet	Dover	Erith	Deal	South West	North East	The Stacks	Pyramid Rock	Outer Sisters	Inner Sisters	Sentinel	Little	Inner Pasco	Middle Pasco	Outer Pasco	Babel	Cat
C. letronioides											x							
C. lithophila																		
C. lutea																		
C. maccarthya		x																
C. marchantiorum			x		x													
C. marina	x	x		x	x		x								x		x	
C. mccarthii					x						x						x	x
C. michelagoensis					x													
C. pulcherrima																		
C. rubelliana																		x
C. sublobulata	x				x			x									x	
C. subluteoalba																		
C. tavaresiana					x													
C. tomareeana							x	x	x				x	x	x			
C. whinrayi	x	x	x					x			x	x	x		x		x	x
C. yarraensis																		
C. yorkensis	x																	
Unnamed specimens	x	x	x	x	x	x		x	x		x	x					x	x

Species	Storehouse	Prime Seal	Low Islet	Flinders	Chalky	Mile	Isabella	Little Chalky	Green	Kangaroo	Chappelle	Badger	Little Goose	Goose	Isabella Reef	Beagle Reef	Long	Woody
C. letronioides																		
C. lithophila												x						
C. lutea				x														
C. maccarthya																		
C. marchantiorum																		
C. marina	x			x							x	x	x					
C. mccarthii		x	x	x						x				x				
C. michelagoensis				x							x							
C. pulcherrima		x		x														
C. rubelliana																		
C. sublobulata		x						x		x	x				x			
C. subluteoalba						x												
C. tavaresiana																		
C. tomareeana				x									x		x	x		
C. whinrayi	x		x	x		x		x	x	x	x		x		x		x	
C. yarraensis		x																
C. yorkensis		x								x								
Unnamed specimens		x		x	x	x	x			x	x			x				

Species	Little Green	Big Dog	O.A.O. Reef	I.A.O. Reef	Doughboy	Cape Barren	Battery	Night	Gull	Preservation	Rum	Sea Lion	Penguin	Clarkes	Spike	Cygnet	Little Swan	Swan
C. letronioides																		
C. lithophila														x				
C. lutea																		
C. maccarthya																		
C. marchantiorum										x								
C. marina		x			x									x				
C. mccarthii												x	x					
C. michelagoensis																		
C. pulcherrima										x				x				
C. rubelliana																		
C. sublobulata			x	x		x									x		x	x
C. subluteoalba																		
C. tavaresiana																		
C. tomareeana						x			x		x							
C. whinrayi	x				x	x		x	x		x	x		x		x		
C. yarraensis																		
C. yorkensis																		
Unnamed specimens	x					x	x					x	x	x	x		x	x

Ecological role of large mammalian predators in south-east Australia

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Abstract

Large mammalian predators (Dingo/Dog, Tasmanian Devil, Red Fox, Cat) play a major ecological role in south-east Australia as informed by experience with predator exclosures. Excluding Dogs, Red Foxes and Cats collectively causes increased mammalian herbivore pressure on vegetation with adverse effects on biodiversity. The exclosures indicate that large mammalian predators normally limit their prey, thereby protecting edible plants and their dependent species. Control of these predators should be generally avoided in native vegetation or undertaken to assist threatened fauna with caution due to potential habitat damage. (*The Victorian Naturalist*, **136** (1), 2019, 29–40)

Keywords: mammal, herbivore, predator, prey, ecology

Introduction

Ecosystems are influenced or shaped by predators. Food webs (trophic structures) and predator-prey population dynamics are varied, complex and central to ecosystem function. Each animal species has an evolved trophic strategy consisting of many adaptations to its predators and food sources. Top predators can limit populations of smaller mesopredators, preventing them from overconsuming their small prey. Predators can also limit herbivores, preventing the overconsumption of plants and vegetation that support overall biodiversity (Hairston *et al.* 1960, Estes *et al.* 2011, Ripple *et al.* 2014).

Trophic imbalance occurs when one trophic level becomes disproportionately large or small, causing adverse trophic cascade effects in adjacent levels, including loss of species and disrupted ecosystem function (see Terborgh and Estes 2010). It may be temporary or chronic and starts when a key population experiences (a) significant change in bottom-up control—food supply, or (b) significant change in top-down control—predator pressure. Trophic imbalance can be catastrophic when herbivores without predators irrupt, destroying vegetation and depriving themselves and many other species of food and habitat.

In line with a global pattern, mammalian carnivores include major ground-dwelling predators in Australia (Glen and Dickman 2014). Their depletion or loss, which usually results from human activity, may cause an

- increase in number or change in behaviour of smaller predators—mesopredator release, with adverse impacts on small fauna, for example, Red Fox without Dingo (Letnic *et al.* 2009), Cat without Dingo (Johnson 2015), Cat without Red Fox (Risbey *et al.* 2000; Robley *et al.* 2004; Molsher *et al.* 2017);
- increase in number or change in behaviour of herbivores—herbivore release, with adverse impacts on flora and fauna (Cheal 1986; Coulson 1988, 2001, 2007; de Munk 1999; Coates 2008; Carr *et al.* 2010; Dexter *et al.* 2013; Yugovic 2015, 2016; Lindenmayer *et al.* 2018).

Many of the 18 native and eight human-introduced (alien/novel) mammalian herbivores in south-east Australia increase in number when mammalian predator pressure is relaxed (Yugovic 2015, 2016). Herbivore release becomes herbivore imbalance (overabundance) when site flora or fauna are lost to these herbivores, directly through consumption of plants or indirectly through habitat alteration. The role of large mammalian predators in limiting these herbivores is informed by evidence from predator exclosures.

Large mammalian predators are defined here as the Dingo/Dog, Tasmanian Devil, Red Fox and Cat in order of weight. Quolls, Short-beaked Echidnas and Platypus are medium-size, while Water Rats, rats, Brush-tailed Phascogales, microbats, dunnarts and antechinuses are small predators. Medium and small mammalian predators may also limit herbivores including invertebrates, but we have only exclosure evidence for large mammals. Scientific names of flora and fauna are in Appendix 1.

South-east Australia, as defined here, is the eastern Bassian biogeographic province (Ebach 2017), comprising areas receiving above about 500 mm rainfall including the temperate areas of south-east South Australia, much of Victoria, south-east New South Wales and Tasmania.

Predator exclosures

Predator exclosures are predator-proof fenced areas that exclude Dogs, Red Foxes and Cats in order to protect native fauna from these predators, sometimes with considerable success (Fig. 1). The protected fauna either pre-existed on the site or were deliberately reintroduced or introduced. The exclosures are run by government agencies, a university and one commercial business (Table 1). The first exclosure, Warrawong in the Mount Lofty Ranges, peaked at 34 ha and was finally 11 ha in area; it began operation in 1969 and closed in 2013. The first existing large exclosure, within Woodlands Historic Park, commenced in 1987.

The exclosures are of sufficient size (mean = 260 ha, range = 30–485 ha) to evaluate the effects of resident herbivores. Most (7/8) of the large (≥30 ha) existing predator exclosures in the region have experienced herbivore imbalance. The exception is Hamilton Community Parklands where herbivores have been controlled from the outset. A new exclosure at Tiverton near Mortlake is being prepared and it is too early to detect effects; in any case herbivores will be controlled or eliminated. The exclosures in relation to their surroundings provide an informal replicated experiment on the effects of herbivores under reduced predator pressure (n = 7).

Direct observations at two sites (Cranbourne Gardens, The Briars) and/or discussions with site managers or experts (all sites), along with the known distribution of novel predators and inferences made by comparisons with surrounding areas at present and prior to the exclosure, confirmed that

- Aboriginal predation had ceased and the novel mammalian predator Dingo had been eradicated;
- novel mammalian predators (Dog, Red Fox, Cat in various densities) were the major ground predators;
- native and novel mammalian herbivores were the major plant consumers;
- vegetation and fauna habitats were relatively stable with generally healthy tree canopies.

Exclosures exclude or attempt to exclude ground predators only. In practice they are not always fully successful due to open gates and/or recurrent breaches in fences, sometimes resulting in low rather than zero predator density. Native diurnal and nocturnal aerial predators still have access.

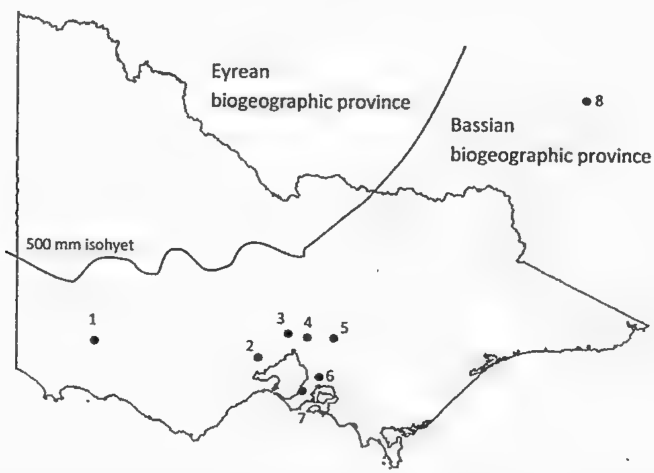

Fig. 1. Predator exclosures ≥30 ha: 1 Hamilton Community Parklands, 2 Mt Rothwell, 3 Woodlands Historic Park, 4 La Trobe Wildlife Sanctuary, 5 Coranderrk Bushland Reserve, 6 Cranbourne Gardens, 7 The Briars Wildlife Sanctuary, 8 Mulligans Flat Woodland Sanctuary.

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Table 1. Predator exclosures and herbivore damage

Exclosure management ecological vegetation class	**Herbivore[1,2]**	**Herbivore damage[3]**
Mulligans Flat Woodland Sanctuary Gungahlin 485 ha ACT government *Grassy Woodland*	Eastern Grey Kangaroo Red-necked Wallaby Black Wallaby	Before exclosure, severely grazed ground layer existed due to large kangaroo numbers (McIntyre *et al.* 2010); after exclosure wallabies contributed significantly to grazing pressure (S McIntyre, pers. comm., 2018)
Mt Rothwell Little River 420 ha Mt Rothwell Biodiversity Interpretation Centre *Hills Herb-rich Woodland*	Eastern Grey Kangaroo Red-necked Wallaby Black Wallaby Brush-tailed Rock-wallaby Rufous-bellied Pademelon Common Brushtail Possum European Rabbit	Tree canopy damage (while Red Box is relatively possum-resistant); severely grazed ground layer, particularly by rabbits in 2014 (not currently due to control).
Woodlands Historic Park (Back Paddock) Greenvale 400 ha Parks Victoria *Hills Herb-rich Woodland*	Eastern Grey Kangaroo Black Wallaby Common Brushtail Possum European Rabbit	Tree canopy damage and loss (River Red Gum); severely grazed ground layer, site extinction of reintroduced Eastern Barred Bandicoot due to loss of cover (reason for exclosure, since reintroduced) (Coulson 2001, 2007; D Gilmore, pers. comm., 2016; D de Angelis, pers. comm., 2018; author, pers. obs. 2018), Fig. 2.
Cranbourne Gardens Cranbourne 250 ha Royal Botanic Gardens Victoria *Heathy Woodland* *Grassy Woodland*	Eastern Grey Kangaroo Black Wallaby Common Wombat Common Brushtail Possum Eastern Ringtail Possum Swamp Rat European Rabbit	Tree canopy damage (Narrow-leaf Peppermint, Silver-leaf Stringybark, one large tree saved by possum band); severely browsed shrub layer; heavily grazed ground layer. Wombat gates are kept open to release excess wallabies but this allows in more foxes, which has resulted in severe decline in Southern Brown Bandicoot (reason for exclosure) as wallabies have eaten their shelter (Yugovic 2016; author, pers. obs., 2018).
Coranderrk Bushland Reserve Badger Creek 142 ha Zoos Victoria *Grassy Forest* *Riparian Forest*	Eastern Grey Kangaroo Black Wallaby Common Wombat Common Brushtail Possum Eastern Ringtail Possum Swamp Rat European Rabbit	Tree canopy damage and loss (Narrow-leaf Peppermint); severely browsed shrub layer (except for relatively resistant Yarra Burgan which is overabundant due to reduced competition and now reducing diversity); heavily grazed ground layer (de Munk 1999, Carr *et al.* 2010; author, pers. obs., 2017).
The Briars Wildlife Sanctuary Mount Martha 95 ha Mornington Peninsula Shire *Grassy Woodland*	Eastern Grey Kangaroo Black Wallaby Common Brushtail Possum Eastern Ringtail Possum Swamp Rat European Rabbit	Tree canopy damage and loss (Narrow-leaf Peppermint, Swamp Gum, Snow Gum, while Manna Gum has possum sensitive and resistant forms as elsewhere, several large trees saved by possum bands); heavily grazed ground layer, orchid loss (author, pers. obs., 2018), Fig. 3.
La Trobe Wildlife Sanctuary Bundoora 30 ha La Trobe University *Plains Grassy Woodland*	Eastern Grey Kangaroo Common Brushtail Possum	Tree canopy damage (River Red Gum, both large trees saved by possum bands), severely grazed ground layer, endangered natural Matted Flax-lily suppressed and unable to flower (author, pers. obs., 2014).

1. Primarily herbivorous Common Brushtail Possum is included.
2. Herbivore has contributed to herbivore pressure, not necessarily currently due to control.
3. Damage has occurred, based on written accounts, discussions with managers or experts (all sites) and personal observations.

Fig. 2. River Red Gum defoliated by Common Brushtail Possums, Woodlands Historic Park, Greenvale, June 2018.

Fig. 3. Manna Gum woodland canopy killed by Eastern Ringtail Possums; possum-resistant form of Manna Gum in background, The Briars Wildlife Sanctuary, Mount Martha, May 2018.

The results of the exclosures (summarised in Table 1) are generally increased mammalian herbivory with a syndrome of negative trophic cascade effects which, depending on site characteristics and site herbivores and their level of control by management, may include:

- increase in native and novel grazers (e.g. kangaroos, wombats, rabbits);
- increase in native browsers (wallabies, possums);
- loss of herbivore condition and sometimes death by starvation;
- loss of trees depending on species;
- loss of shrubs;
- loss of ground layer vegetation, including orchids to digging rats;
- loss of ground cover habitat for fauna, including bandicoots;
- increase in establishment of introduced weeds (novel plants), leading to weed dominance of vegetation;
- increase in soil erosion on slopes.

These effects characterise a predator loss ecological dysfunction syndrome.

Such significant shifts have not been seen or reported from outside the exclosures. Mulligans Flat underwent little or no shift inside the fence as kangaroos were already abundant before the exclosure: 'Biomass estimates indicated extremely high grazing pressure, sufficient to negatively affect the habitat quality for ground-dependent fauna and some soil processes' (McIntyre *et al.* 2010: 329). Ongoing management of kangaroo populations enabled two levels of grazing pressure to be maintained experimentally after the removal of foxes (McIntyre *et al.* 2014). However, the increase in wallaby populations combined with the drought after 2011 has made grazing pressure difficult to control until impediments to wallaby management are overcome (S McIntyre, pers. comm., 2018).

The type of impact depends on the herbivore, with possums becoming markedly more ground-active and frequently damaging or killing trees, and all herbivores inhibiting canopy tree seedling recruitment. The severity of impact is determined by herbivore density in relation to edible vegetation, this density being influenced by factors such as physical shelter, available water, weather events and management control actions.

Discussion

Experience with predator exclosures

Predator exclosures may provide important backup populations of threatened fauna, opportunities to see rare species, and opportunities to research trophic cascades through manipulation experiments.

In order to prevent herbivore damage to the habitat of the protected mammal species and site ecosystem, corrective actions have been carried out, attempted or are proposed at all sites, including culling, sterilisation, reintroduction of native predators and possum (protective) banding of trees. Whether they work or not, these measures are not practicable outside exclosures in the broader landscape. Although these exclosure-specific issues are locally important, it is the knowledge that herbivore imbalance is a chronic problem in exclosures, and what this implies about the rest of the region, that is of interest here.

Before they were established, the exclosure sites had lost their predator-naive fauna and their herbivore and vegetation levels were relatively stable under novel predator pressure. The systems appeared to be in dynamic equilibrium. Possum-sensitive eucalypt canopies were generally healthy as evidenced by the existence of many large trees that were later killed within the exclosures—they could not have survived and grown to those sizes with possum overbrowsing. Canopy trees were often regenerating after the withdrawal of livestock grazing. Kangaroos were in moderate densities except for peri-urban areas with local Dog regulations. The contributions from the Dog, Red Fox and Cat in providing that essential background predator pressure would have varied with site characteristics and herbivores present.

The evidence from the predator exclosures indicates that the loss of mammalian ground predators causes trophic imbalance—an ecological dysfunction caused by a drop in system predator pressure (Table 1). Herbivore populations without predators generally increase to unsustainable levels resulting in the loss of food and habitat for themselves and other species (Forsyth and Cayley 2006). These sometimes catastrophic disruptions suggest that ecosystems with mammalian herbivores need corresponding mammalian predators for

stability and diversity, in line with a global pattern (see Terborgh and Estes 2010). A stable trophic relationship between the ecosystem mammals regardless of species appears to be necessary to maintain flora and fauna diversity over large areas.

The difference predators make is amply demonstrated by Woodlands Historic Park, which has an internal exclosure, the Back Paddock. Mature River Red Gum woodland occurs inside and outside the exclosure, allowing comparison. Inside the exclosure, the ongoing loss of mature and immature red gums to brushtail possums, ringbarking by rabbits, severe grazing by rabbits, kangaroos and wallabies, and accelerated soil erosion combine to make an ecological disaster. It will take centuries to get living large trees back, assuming any regrowth can survive the herbivores. There has been little or no eucalypt recruitment of any species since the exclosure was established. Of the existing trees, stands of Grey Box and scattered Yellow Box are mostly only lightly browsed while the red gum woodland is overbrowsed in general, indicating a possum preference for, and susceptibility of, River Red Gum. The 'predator landscape' outside the fence is obvious from its generally healthy mature trees, continuous canopy tree recruitment and higher ground layer plant cover. Occasional trees are overbrowsed, suggesting that foxes only barely control brushtail possums.

The exclosure experience implies that if the novel mammalian predators Dog, Red Fox and Cat were to suddenly disappear, vast areas of the mainland would look like the exclosures. There might be a plague of rabbits to start with. Eucalypt tree canopies would decline over large areas due to overbrowsing. Many lowland species would be at risk, including River Red Gum, Silver-leaf Stringybark, Yellow Gum, Yellow Box, Messmate Stringybark, Swamp Gum, Snow Gum and Narrow-leaf Peppermint. Some eucalypts, such as Southern Blue Gum and Coast Manna Gum, are resistant to possums but relished by Koalas, while Red Box is relatively resistant to vertebrate herbivores. Flora and fauna would be depleted or lost, ground layers would be stripped and erosion would accelerate. Recruitment of canopy trees would be rare or non-existent.

Whether the herbivores would eventually reach equilibrium with their new, devastated and predator-free landscape is hypothetical as such habitats do not exist outside exclosures in Australia. The situation would be unprecedented as predators have controlled these herbivores and their ancestors over evolutionary time. In North America, New Zealand, and elsewhere, the consequence of human-induced mammalian herbivore imbalance is loss of biodiversity (see Stolzenburg 2008; Ripple *et al.* 2010).

Apart from some accounts (Table 1), the exclosure experience is not well documented, for several reasons:

- most exclosures have little or no baseline ecological data. Exceptions include Mulligans Flat (e.g. McIntyre *et al.* 2010). The relevant variables to measure were (a) mammalian predator and herbivore density and biomass by species, and (b) plant cover and biomass by species and vegetation layer;
- there was no awareness that the site ecosystem was predator dependent;
- managers are seldom funded to monitor, document and publish the results of their work and, in any case, they or their employers may not wish to publicise their ecological dysfunctions or the consequential culling of mammalian herbivores, especially native species;
- there is a tendency to view each exclosure's imbalance problems as being unique when they are not.

Herbivores

Herbivores impose a herbivore regime consisting of various forms of plant biomass reduction. In deciding where to feed, they weigh the pain of hunger against the fear of predators—the herbivore prey dilemma.

Mammalian herbivores are vital for ecosystem stability and diversity in south-east Australia by controlling vegetation cover. Kangaroos limit grass cover and wallabies limit shrub cover, thus facilitating ground layer plant diversity (J Kirkpatrick, pers. comm., 2018). Swamp Rats eat the rhizomes of sedges with the potential for overdominance such as Sandhill Sword-sedge and Thatch Saw-sedge (author, pers. obs., 2018).

However, several native and novel mammalian herbivores have become overabundant in free-range populations under reduced predator pressure. These include Eastern Grey Kangaroo, Western Grey Kangaroo, Black Wallaby, Koala, Common Brushtail Possum, Eastern Ringtail Possum and Swamp Rat (Yugovic 2015). For example, Koalas reintroduced to Cape Otway in 1981 without their predators (Aboriginal people and Dingoes) have killed their Manna Gum woodland food tree canopies and starved in large numbers, prompting euthanasia programs (e.g. Smith 2015).

While predator exclosures provide ecological insights, so do herbivore exclosures. For example, recovery of native vegetation inside kangaroo exclosures in Hattah-Kulkyne National Park has shown that large uncontrolled populations of Western Grey Kangaroo reduce biodiversity (Cheal 1986).

Without predators and with enough physical shelter, mammalian herbivores generally increase, sometimes exponentially as with kangaroos in Woodlands Historic Park (Coulson 2001), until culling is undertaken or declining food supply slows down breeding. With poor nutritional conditions kangaroos may cease to breed (Poole 1983). Female brushtail possums may produce one litter per year instead of two (Menkhorst 1995), which may explain why mass deaths of possums are not seen. However, the larger population, compounded by the longer life expectancy of each animal, is by then already causing chronic damage. With preferred food plants in decline, the hungry herbivores may switch to less preferred species and maintain a population size that prevents recruitment of preferred food species, including canopy trees.

Livestock grazing is a managed herbivore imbalance in favour of the livestock. Many native flora and fauna species have been depleted or lost to sheep grazing in particular (e.g. Kirkpatrick and Bridle 2007). Most (6/8) of the exclosure sites were previously grazed by sheep and their sheep-sensitive flora are likely to have been depleted or lost before the exclosures were established. The herbivore impacts we see in the exclosures today reflect similarities and differences between the native and novel herbivores. For example, kangaroos severely graze the ground layer as did the sheep but, although sheep prevented tree seedling recruitment, they could not climb the trees and defoliate them like possums.

Some areas naturally lack native mammalian herbivores and corresponding mammalian predators. Subalpine Snow Gum woodland does not support Koalas or possums, partly due to a tendency for Snow Gum not to form tree hollows large enough for possums at such high elevations and for snow cover to inhibit animal movement (J Morgan, pers. comm., 2018; I Mansergh, pers. comm., 2018). Areas above the tree line—alpine areas—have no native mammalian herbivores, even Common Wombats, and so have an unusual ecology shared with lakes, swamps and coastal islands in the lowlands. However, damaging novel megaherbivores, Horse and Sambar Deer, are seasonally present in the high country.

Impacts of predators

It is widely accepted that the Red Fox and Cat have a major detrimental impact on the Australian fauna at the continental level (Dickman 1996; Woinarski *et al.* 2015). However this appears to be less so in the high rainfall southeast, possibly because the generally denser vegetation provides better protection from predators.

Most fauna of the eastern Bassian biogeographic province have survived the transition to novel predators (DELWP 2018), predator-adapted species that can coexist with the new predators without being dependent on conservation management. The replacement predators came with a cost. The Dingo probably wiped out the Thylacine and Tasmanian Devil and possibly the flightless Tasmanian Native Hen on the mainland (Johnson 2015). Similarly, the Red Fox may have eliminated the Rufous-bellied Pademelon, Southern Bettong and Eastern Barred Bandicoot, as evidenced by their presence in Tasmania, which has no foxes. The Cat is not known to have caused an extinction; however, it spreads disease toxoplasmosis to native mammals (Brunner *et al.* 1981). Some conservation dependent evolutionarily naive species also have populations that are significantly more suppressed now than they were by the native predators.

A global review of predator-prey manipulation experiments found alien predators to be more harmful to prey populations than native predators, and they 'can impose more intense suppression on remnant populations of native species and hold them further from their predator-free densities than do native predators preying upon coexisting prey' (Salo *et al.* 2007). This is presumably so in many cases, but the original full predator suite of south-east Australia is not there to compare, and the only cases included from south-east Australia are Bush Rat, which doesn't increase with fox control (Banks 1999), and Eastern Grey Kangaroo, which does (Banks *et al.* 2000). Neither prey species is threatened, and kangaroos actually require predator control as shown by their overabundance within predator exclosures.

The numbers of native wildlife taken by Red Foxes and/or Cats are large but difficult to estimate (RMIT ABC 2014). These numbers should be compared with estimated numbers of prey taken by native predators before the arrival of the Red Fox and Cat to make sense. Eastern Quolls were 'one of the commonest of all the bush animals' in the Melbourne area in the 1850s (Wheelwright 1861) and were presumably eating large numbers of prey such as native rats. Regardless of the actual number, most progeny of herbivores must succumb to some form of early mortality or there would be a vast overabundance of herbivores. Consider that an average female ringtail possum produces some 10 progeny during her lifetime based on average longevity, litter size and litter frequency (see Menkhorst 1995); in a stable population an average of only two offspring survive to maturity. Similarly, a Swamp Rat produces some 20 progeny of which 18 die young in a stable ecosystem.

Few herbivores survive their predators. Even if they make it to maturity, they may be picked off later when old and weak. As visibly starved individuals or carcasses of most prey species are seldom seen in free-range populations exposed to predators, it would appear that starvation is not usually a major cause of mortality. Predation is a natural process so the numbers of wildlife taken by predators are not necessarily alarming from an ecological perspective, since the removal of excess animals is essential in stable ecosystems. What matters more is the population size of any threatened native fauna.

Tasmania

If the Dingo were to establish in Tasmania it could eliminate the evolutionarily naive Tasmanian Devil as it evidently has on the mainland (Johnson 2015). Similarly, if the Red Fox were to establish it could eliminate the Rufous-bellied Pademelon, Southern Bettong and Eastern Barred Bandicoot, which would also be disastrous. In any case, devils appear able to eliminate foxes by entering fox dens and eating the cubs (DoEE 2017).

Herbivores are not often seen as a conservation problem in Tasmania, an exception being Maria Island (DPIPWE 2017a). This may be due to a level of control by marsupial predators and Cats experiencing mesopredator release without the Thylacine, supplemented by human culling of marsupial herbivores and rabbits. However, Common Brushtail Possums cause or worsen tree decline in eastern Tasmania (RPDC 2003) and grazing by cattle, sheep and sometimes macropods threatens many flora (DPIPWE 2017b, 2018a).

Mammalian herbivores were once primarily controlled by Aboriginal people, Thylacines, devils and quolls. Tasmania is now effectively a large predator exclosure in which predation by humans and Thylacines has ceased. Humans legally cull large numbers of herbivores in primary production areas (DPIPWE 2018b), which is a form of surrogate predator pressure. Devils and quolls are important predators but, even before the emergence of devil facial tumour disease, their predation was apparently insufficient as there was significant tree decline. As the staple diet of Cats is usually rabbit (DPIPWE 2013), Cats may assist in limiting the herbivore regime.

The herbivore regime in Tasmania compared to the mainland has not been studied, but high macropod levels and heavy herbivore pressure on vegetation have been noted by ecologists (e.g. D Gilmore, pers. comm., 2016; M Dell, pers. comm., 2018). This may be a Thylacine legacy effect. The trophic ecology model predicts that if a top predator is removed there are trophic cascade effects. The balance between the herbivores and vegetation may shift unless

mesopredators increase to maintain system predator pressure, which appears to have happened to some extent in Tasmania.

There are no predator exclosures in Tasmania that would elucidate the role of the existing predators. However, on Maria Island, intense grazing from macropods introduced in the 1960s has degraded habitats, despite the presence of Cats. Devils, first introduced in 2012, are likely to be impacting on the recruitment of all marsupial herbivore populations and the annual culling of macropods has been suspended (DPIPWE 2017a).

The Dingo appears to be a mainland ecological analogue of the Thylacine, and the Red Fox an analogue of the Tasmanian Devil. Just as the Tasmanian Devil could coexist with the Thylacine, the Red Fox can survive with the Dingo. Where Dingo/Dogs and Thylacines are missing kangaroos become overabundant. The fox and devil have limited effect on kangaroos, which justifies culling them where Dingo/Dogs and Thylacines are missing. The fox and devil are ecologically similar opportunistic predators and scavengers with key differences. The larger devil is more adapted to large prey/carcasses by having different jaw musculature, bone structure and teeth. The devil may eliminate the fox but may not survive the Dingo, which could rule out its reintroduction to most of the mainland. The fox has several sensitive prey species but may be better at controlling brushtail possums.

Role of predators

Predators impose a predator regime consisting of various forms of prey biomass reduction, lowering prey numbers and a 'landscape of fear' that affects prey behaviour (Laundré *et al.* 2010). The predator loss syndrome indicates that predation is a primary form of mammalian herbivore population control in south-east Australia, consistent with a global pattern (see Terborgh and Estes 2010).

Humans are, or once were, the ultimate mammalian predator. Aboriginal people preyed on Dingoes (Johnson 2015), rendering them mesopredators. Aboriginal hunting, supported by the Dingo and a range of native predators, is likely to have once controlled many herbivore populations in Australia. We have no reports by early Europeans of mammalian overpopulation or mammal-induced vegetation loss such as stripped ground layers or dead tree canopies. There may have been a predator-prey balance between the Humans, Dingoes and native predators and the herbivores which, along with Aboriginal mosaic burning, could account for the large trees and rich biodiversity described by early Europeans (see Hateley 2010). Predation by Humans (for food) has all but ceased, but culling of certain herbivores, mainly rabbits and kangaroos, occurs in some areas.

Part of a global pattern of large mammalian predator loss in regions occupied by people (Wolf and Ripple 2017), the large native mammalian predators of south-east Australia are extinct or their ranges have contracted. The Marsupial Lion is long gone. Europeans sent the largest remaining carnivore, the Thylacine, extinct through the bounty system and habitat loss (Paddle 2000) and are responsible for several smaller predator declines. Reasons vary with species and include hunting, burning, poisoning, habitat loss and alteration, disease (Eastern Quoll), roadkill, and competition with and predation by novel predators. Much of the mammalian predator pressure is now exerted by novel predators, robust species that can survive or even thrive with or near humans.

The negative effects of predator exclusion indicate a widespread positive influence of novel predators in many contemporary bushland ecosystems. Rather than being pest animals with no redeeming features, they appear to provide an ecosystem service by limiting herbivores in these novel ecosystems. The canids (Dingo, Dingo-Dog, Dog, Red Fox) are important in regulating ecosystems throughout the mainland, particularly by controlling the numbers and behaviour of macropods and brushtail possums, and possibly by preventing mesopredator release of the Cat. The only felid (Cat) may be the least important predator as it doesn't effectively control herbivores larger than rabbits. Continual canid and felid predator pressure on herbivores is pervasive but not always obvious except when it is removed and systems are damaged by excess herbivory.

A general lack of awareness of the secondary ecosystem effects of predator exclusion may have extended the life of an antipredator management paradigm. It is evidently not a good

idea to remove all mammalian ground predators, particularly foxes, where predator pressure from Humans, Dingoes, quolls and goannas is missing. Furthermore, there is evidence that foxes suppress Cats, which benefits small native fauna (e.g. Risbey *et al.* 2000). Fox control is either non-existent or is generally temporary, localised or ineffective in areas where Dingoes and native predators are locally extinct, otherwise the result could be catastrophic.

The exclosures, for example, demonstrate that foxes often protect tree canopies from possums. A long-term study of the Red Fox diet in southeast Australia found that it consists largely of insects, rats, rabbits, possums and plant material (Davis *et al.* 2015). Overall frequencies of native fauna of listed conservation significance in fox scats were generally <0.2% except for Broad-toothed Rat which was 1.5%, with higher frequencies in some regions. Brushtail and ringtail possums had a combined frequency of 13% with up to 35% in West and South Gippsland. These observations and data suggest that mature eucalypt woodlands, having hollows for brushtail possums (and many other fauna), depend on foxes to prevent canopy destruction by excessive resident possums. The Red Fox is a surrogate top predator performing a keystone predator role similar to that of the previous Dingo, and before then the Thylacine and Tasmanian Devil, and now it protects the trees from possums. There is no redundancy in these fox-dependent ecosystems as there are no practicable alternatives to the Red Fox.

The positive role of foxes in ecosystems has been seldom researched but is sometimes accidentally discovered. At Jervis Bay, for example, intensive fox control allowed a tenfold increase in Black Wallabies, which are eating out the understorey except for unpalatable Austral Bracken. The forest habitat may be transformed into 'a low diversity bracken fern parkland… through a trophic cascade, similar to that caused by overabundant deer in the northern hemisphere' (Dexter *et al.* 2013: 1). This fox control program also caused a collapse in mammal fauna that apparently included the Greater Glider (Lindenmayer *et al.* 2018).

The predator loss syndrome indicates that control of large mammalian predators, particularly the Red Fox where it is surrogate top predator in lieu of the Human and Dingo, should be generally avoided in native vegetation where possible, or undertaken to assist threatened fauna with caution due to the potential for trophic imbalance leading to habitat damage and depletion or loss of flora and fauna. Control should be accompanied by monitoring of mammalian herbivore pressure, vegetation structure, sensitive species and habitat conditions.

Where there are no mammalian herbivores, fox control may have no negative impacts and can be beneficial. For example on Middle Island, close to the mainland at Warrnambool, fox deterrence using Maremma dogs is assisting nesting Little Penguins (Wallis *et al.* 2017). The penguin colony appears to have established after potential predation by Aboriginal people and Dingoes had ended in the area.

There are strong ethical, scientific and cultural reasons for enhancing the currently persisting intact Dingo populations in Victoria where contiguous national parks are over one million hectares in area, notably in semiarid and mountainous areas. While legally protected in remote eastern Victoria, the current widespread persecution should be replaced by better protection (I Mansergh, pers. comm., 2018).

Where there is no mammalian herbivore imbalance, which applies to much of the Bassian region, it is likely due to herbivore-resistant vegetation, the absence of particular herbivores, or a trophic status quo operating effectively with the existing mammalian predators and prey (until an exclosure is created). Novel megaherbivores Horse and Sambar Deer, without megapredators, are overabundant and causing enormous damage. In more remote areas, the novel predators may compete with the remaining native predators, but they all operate in the essential regulation of their mammalian herbivore prey.

For more information:
When predators go missing—rise of the herbivores: native mammalian herbivore imbalance and the predator-prey ecology of southeast Australia (February 2019). <www.spiffa.org/do-ecosystems-need-top-predators>

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Appendix 1. Scientific names of flora and fauna

Flora	
Austral Bracken	*Pteridium esculentum*
Coast Manna Gum	*Eucalyptus viminalis* subsp. *pryoriana*
Grey Box	*E. microcarpa*
Manna Gum	*E. viminalis*
Matted Flax-lily	*Dianella amoena*
Messmate Stringybark	*E. obliqua*
Narrow-leaf Peppermint	*E. radiata*
Red Box	*E. polyanthemos*
River Red Gum	*E. camaldulensis*
Sandhill Sword-sedge	*Lepidosperma concavum*
Silver-leaf Stringybark	*E. cephalocarpa*
Snow Gum	*E. pauciflora*
Southern Blue Gum	*E. globulus* subsp. *globulus*
Swamp Gum	*E. ovata*
Thatch Saw-sedge	*Gahnia radula*
Yarra Burgan	*Kunzea leptospermoides*
Yellow Box	*E. melliodora*

Fauna	
antechinuses	*Antechinus agilis, A. flavipes, A. minimus, A. stuartii, A. swainsonii*
bandicoots	*Isoodon obesulus, Perameles gunnii*
Black Wallaby	*Wallabia bicolor*
Brush-tailed Phascogale	*Phascogale tapoatafa*
Brush-tailed Rock-wallaby	*Petrogale penicillata*
Bush Rat	*Rattus fuscipes*
Cat	*Felis catus*
Common Brushtail Possum	*Trichosurus vulpecula*
Common Wombat	*Vombatus ursinus*

Fauna cont.	
Dingo	*Canis lupus dingo*
Dog	*Canis lupus familiaris*
dunnarts	*Sminthopsis crassicaudata S. leucopus, S. murina*
Eastern Barred Bandicoot	*Perameles gunnii*
Eastern Grey Kangaroo	*Macropus giganteus*
Eastern Quoll	*Dasyurus viverrinus*
Eastern Ringtail Possum	*Pseudocheirus peregrinus*
European Hare	*Lepus europaeaus*
European Rabbit	*Oryctolagus cuniculus*
goannas	*Varanus gouldii, V. rosenbergi, V. varius*
Greater Glider	*Petauroides volans*
Horse	*Equus caballus*
Koala	*Phascolarctos cinereus*
Little Penguin	*Eudyptula minor*
Marsupial Lion	*Thylacoleo carnifex*
microbats	various small insectivorous bats
Platypus	*Ornithorhynchus anatinus*
rats	*Rattus fuscipes, R. norvegicus, R. rattus*
Red Fox	*Vulpes vulpes*
Red-necked Wallaby	*Macropus rufogriseus*
Rufous-bellied Pademelon	*Thylogale billardierii*
Sambar Deer	*Cervus unicolor*
Short-beaked Echidna	*Tachyglossus aculeatus*
Southern Bettong	*Bettongia gaimardi*
Spot-tailed Quoll	*Dasyurus maculatus*
Swamp Rat	*Rattus lutreolus*
Tasmanian Native Hen	*Tribonyx mortierii*
Thylacine	*Thylacinus cynocephalus*
Water Rat	*Hydromys chrysogaster*

Encounter with a Sea Flea *Ampithoe prolata* in Port Melbourne

Though amphipods are common in the sea, akin to insects on land and belonging to the same phylum, Arthropoda, they usually escape our notice as they are very small and occur in fine sand or within the water column where they live among algae. They are often called sandfleas, sandhoppers and side swimmers.

When we lift up stranded seaweed or seagrass, we often see amphipods jumping in all directions. Similarly, if we move the damp leaf litter in the garden we are likely to come across the brown Talitrid amphipods *Arcitalitrus sylvaticus* (Haswell 1879) lurching to get back into the damp conditions necessary for their gills to absorb oxygen.

When the tide is low and a high pressure cell above makes the sea as smooth as satin, I visit the seashore to sieve for amphipods. Such times are ideal as there is no wind to ruffle the water in the 'look box', which would make it impossible to see features of amphipods and make photography difficult.

In 2009, I encountered a large amphipod (Fig. 1) in Greenwich Bay, Newport, Victoria. As I looked at it through the microscope I nicknamed it Mr and Mrs Bigskirts on account of the large, deep coxal plates along the side of the body (Fig. 2). These plates are like shields protecting the proximal/upper parts of the two pairs of claws and five pairs of legs, or, as in amphipodal parlance, gnathopods and pereopods respectively. At that time, available literature provided no match fitting the description of *Ampithoe prolata*.

Since then, I acquired the scientific description of *Ampithoe prolata* (Hughes and Peart 2013) which belongs to the family Ampithoidae, and I have encountered an ovigerous female of the species deeply encrusted with 40-odd small brown eggs in seagrass in Hobsons Bay off Williamstown.

On 14 July 2018, a neighbour and I took advantage of ideal weather conditions and visited Port Melbourne. As we examined a clump of blue mussel *Mytilus galloprovincialis planulatus* stranded at the high tide mark by recent heavy seas, I observed the rear end and leg of a crustacean in the dark murky recess of a dead bivalve,

Fig. 1. Upper: *Ampithoe prolata.* **Lower:** Drawing of *A. prolata* female measuring 15 mm from head to telson.

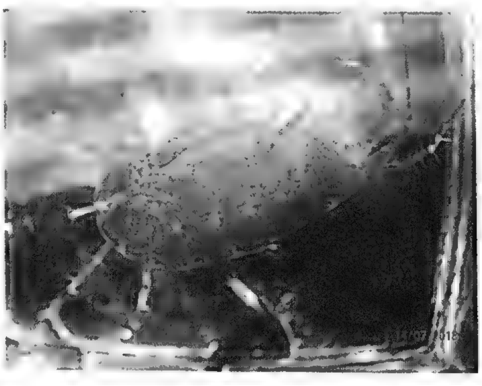

Fig. 2. Specimen showing coxal plates 1 to 5, relative size, pattern and pigmented areas (brown dots) with unpigmented blotches and plain seasonal coxal plate.

Barbatia pistachio, attached to the mussels by a byssus thread. I dislodged a large amphipod from the bivalve using a soft brush and placed it into a glass look box. The amphipod was about 16 mm long and had a clump of milky brown fuzz adhering to the underside of her thorax. I realised with surprise that this fuzz was about 40 newly hatched juveniles (Fig. 3). Some of them measured about 1 mm in length and swam into the water column where I trapped them for later photography under a compound microscope. The species was readily identifiable as *Ampithoe prolata* by the characteristic pattern of brown spots and unpigmented blotches (Fig. 4). The species name refers to the elongate carpus of gnathopod 1 in the female (Fig. 5) and the especially long carpus in the male (Fig. 6).

After taking a few pictures, the adult female was returned to the water along with the mussel clump to which she was attached in the hope she and her young would survive.

Fig. 3. Juvenile approximately 1mm in size.

Fig. 4. Head and antennae of a juvenile (arrowed), just visible under the fourth coxal plate. Mouthpart section ventral to head and first gnathopod can be seen as with the pattern of pigmentation (brown dots).

In my experience so far, *Ampithoe prolata* is found in *Heterozostera nigricaulis* in sheltered areas in both muddy and not so muddy places such as Brighton, Williamstown, Newport and Port Melbourne, Victoria.

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Fig. 5. Gnathopod 1 of female, collected at Greenwich Bay.

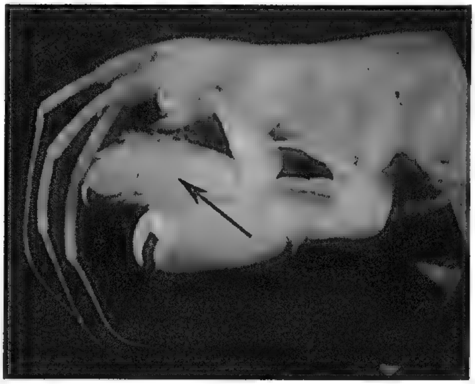

Fig. 6. Side view of male head and gnathopods showing the elongate carpus of the first gnathopod. Specimen collected at Greenwich Bay 2 August 2009.

You can save that spider!

Imagine this: You have just begun to have a shower when you happen to look down and see a very wet Daddy Long-legs spider *Pholcus phalangioides* being swept rapidly towards the drainage hole.

Although it may appear waterlogged and lifeless, you can save it. And it is well worth saving, because its diet consists of common household pests such as clothes moths, silverfish, cockroaches and flies, as well as other spiders (Fig. 1). Ian Temby (2005: 203) states that Daddy Long-legs spiders are harmless and 'can be considered a chemical free pest control service'.

On three occasions while showering, I have removed a sopping wet Daddy Long-legs and placed it on a dry surface, gently arranging it in a standing position. The first spider I saved took about two hours to revive. The second took one hour, and the third, which definitely appeared to be dead, walked away after six and a half hours.

Some spiders live in watery habitats, but even those that dwell in normally dry places do not drown easily. The Australian Museum website notes that 'Spiders can trap a small bubble of air in hairs around the abdomen which aids both breathing and floating ... Funnel-web spiders have been known to survive 24 to 30 hours in water'. In Western Australia, a trapdoor spider *Anidiops villosus* revived about an hour after being removed from a container of water (Cannon 2016). Pétillon *et al.* (2009) found that *Arctosa fulvolineata,* a saltmarsh-inhabiting wolf spider, 'falls into a coma' in order to survive flooding of its habitat.

So, how do you rescue that spider from the shower? It is best to find it and take it away before turning on the taps. In this case, all that is needed is an empty jar or container placed over the spider, and a piece of thin cardboard to slide under the container, preventing escape during transport to an appropriate location. Most spiders are easy to see, but Daddy Long-legs are very spindly and less visible, especially on a coloured surface. If the spider is wet, gently scoop it up on a back brush or mesh sponge and put it on the floor or bath mat before finishing your ablutions. If the spider hasn't revived by the time you step out of the shower, put it on a paper towel or other dry surface, carefully manoeuvre it into a standing position, then leave it alone. It is important not to break the spider's fragile legs, which will not regrow if the creature has reached maturity (Pasquet *et al.* 2011). In a few hours it will probably have departed, ready to prey on more household pests.

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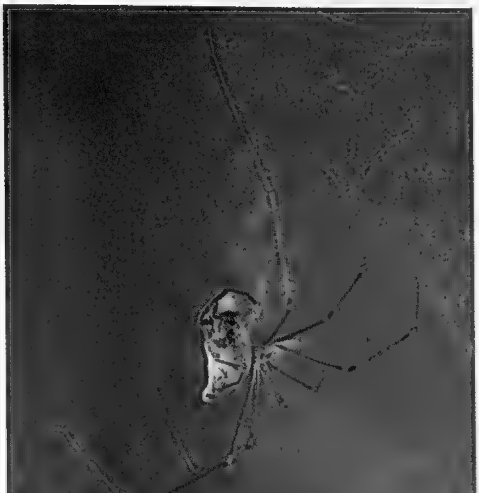

Fig. 1. Daddy Long-legs spider with prey.

The Four Ladies of Prydz Bay: notes on the naming of a submarine formation in Australian Antarctic Territory

Four Ladies Bank in Prydz Bay is an outer bank on the continental shelf of eastern Antarctica (Fig. 1), and has been a trawl site for several marine benthos investigations by Research Survey Vessel *Aurora Australis* of Australian National Antarctic Research Expedition (ANARE) (Bathie and Pett 2019a, 2019b; Quilty 1997).

Four Ladies Bank is an unusually unspecific name in the context of Antarctic features, which are typically named for individuals (mainly men), as are Prydz Bay, the local Amery Depression, Lambert Glacier, and Scullin Monolith (originally Klarius Mikkelsen Mountain). Among the few place names commemorating women is the Ingrid Christensen Coast of Prydz Bay (Fig. 1). No gazetteer, that we can find, names our four ladies, even if it records that the name *honours* the four women present when this underwater bank was discovered by Norwegians in 1937 (Herdman *et al.* 1956). The scarcity of women's names associated with Antarctica has never reflected a lack of interest in Antarctic exploration—the Melbourne *Argus* reported in 1937 (3 April) that the proposed British Antarctic Expedition had attracted 1300 applications from women ('WOMEN WANT TO GO TO POLE... 'NO,' SAYS LEADER').The name of the first woman to step onto Antarctica remained obscure until she was interviewed in old age by Australian Antarctic station leader Diana Patterson (Patterson 1995–1996). Caroline Mikkelsen was present in 1935 on the largest of the Tryne Islands, to raise the Norwegian flag and celebrate with coffee and sandwiches, when her husband Klarius named the Ingrid Christensen Coast after the wife of his employer

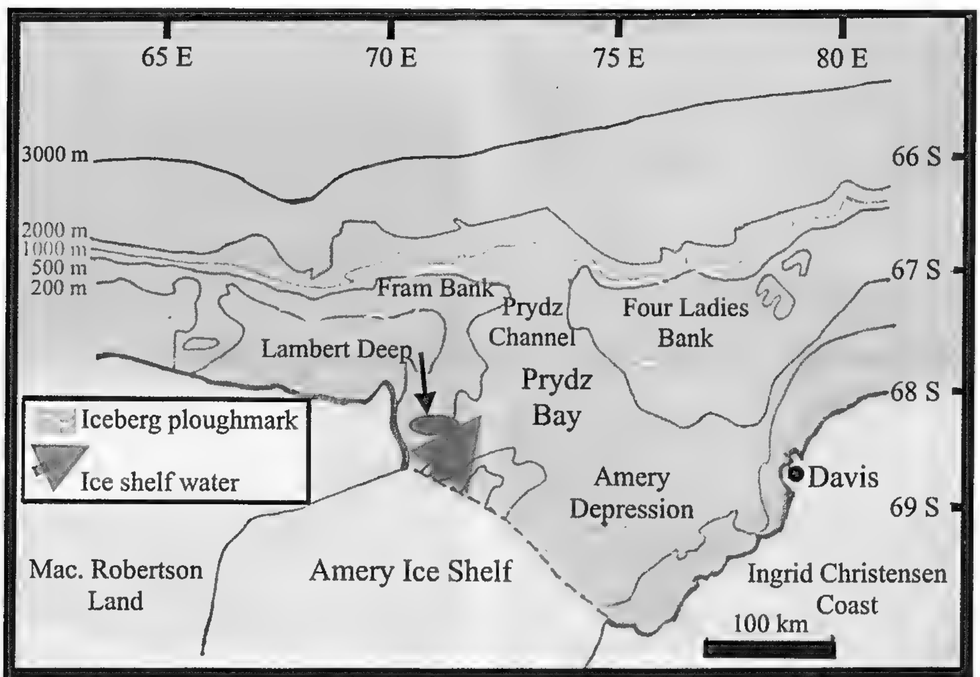

Fig. 1. Summary of bathymetry, iceberg ploughmarks and geographic features around Prydz Bay. After Harris *et al.* (1998) and O'Brien *et al.* (2016).

(Norwegian Polar Institute 2011; Blackadder 2013; Norman *et al.* 1998 cited in Blackadder 2015).

Ingrid Christensen accompanied her husband on four trips to the Antarctic in the 1930s. The Lars Christensen Coast (now Mac. Robertson Land) had already been named after the Norwegian shipping and whaling magnate—also by Klarius Mikkelsen, one of his whaling captains. Lars Christensen (Herdman *et al.* 1956) described to the Norwegian Geographical Society his 'unique pleasure of setting foot on the Antarctic mainland', scrambling from a lifeboat at Klarius Mikkelsen Mountain on 30 January 1937. His personal diary, discovered only recently by his granddaughter, has been translated at the behest of Australian Antarctic Fellowship recipient Jesse Blackadder, revealing that this pleasure was shared by Captain Klarius Mikkelsen himself. Also clambering onto the slippery ledge, watched by softly chattering penguins, were Ingrid Christensen, their 18-year-old daughter Augusta Sofie, and 'the others'. These last are now known to be Ingrid's friend Lillemor Rachlew (who had previously accompanied Ingrid on a voyage to Antarctica), and Solveig Wideroe, wife of the ship's aviator Viggo Wideroe (Fig. 2) (Blackadder 2013).

Four Ladies Bank had been discovered two days earlier. Christensen's ships, primarily pursuing commercial whaling interests, were responsible for soundings and discoveries of many ocean banks. They were also equipped for mapping and photographing thousands of kilometres of Antarctic coastline (Norman 2007). At least six flights over two days were made in this vicinity by the seaplane carried on the *Thorshavn* (Norman 2007). Passengers Lillemor Rachlew and Ingrid Christensen—described by Norwegian historian Hans Bogan, who was also on the expedition, as 'incredibly bold and fearless'—were the first women to see Antarctica from the air (Blackadder 2013). Four Ladies Bank, as a submarine feature, may well have been best appreciated from high above. It is conceivable that that pleasure was

Fig. 2. The Four Ladies L-R: Solveig Wideroe, Ingrid Christensen, Lillemor Rachlew and Augusta Sofie Christensen. Photo Sandefjord Whaling Museum, Norway.

experienced by all four women, and that two of their names (one that of the pilot's wife) were not officially recorded by Lars Christensen, as later they were not, when all four were among the six passengers on a small boat 'who all dreamed of going ashore' (Christensen 1937 cited in Blackadder 2013).

Acknowledgements

Our thanks to Jesse Blackadder who made our joy complete by sending us a photograph of The Four Ladies in the Antarctic (Fig. 2), and to Øyvind Thuresson of Sandefjord Whaling Museum, Norway, for generously allowing us to reproduce it here.

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One Hundred Years Ago

A SCIENTIST IN THE ANTARCTIC

BY DR. GRIFFITH TAYLOR, B.E., B.A., F.G.S, F.R.G.S.

… Microscopic life swarms in these Polar seas. It is stated that there is almost as much protoplasm per acre of ocean as there is in a well-cultivated land crop. Most of this occurs as diatoms and infusoria, forams, and copepods; indeed, almost every floe in its lower layers is stained yellow from the presence of millions of small diatoms allied to Corethron.

… The animal life along the coast has often been described. Weddel Seals were common, especially at the entrance to the Taylor Glacier. Here was a flock of some thirty individuals, and hereabouts also we found a troop of Emperor Penguins awaiting their moulting time. In the moss I was lucky enough to discover the first living insects – some small aptera, about a millimetre long, which I brushed on to seccotined paper, and so embalmed many thousands! These insects must hold the record for hibernation, for they were frozen in an ice film even in midsummer, until I turned them toward the sun, when they moved slowly among the moss hyphae.

From *The Victorian Naturalist* XXXVI, p. 7, May 8, 1919

Australian Natural History Medallion 2018
Sarah Lloyd

The 2018 Natural History Medallion has been awarded to Sarah Jane Lloyd for her contribution to conservation, natural history and education. Sarah was nominated by the Central North Field Naturalists Inc, Tasmania.

Sarah Lloyd is a Tasmanian naturalist, writer and nature photographer with a life-long passion and commitment to the study of natural history, especially birds, and a more recent interest in plants, fungi and acellular slime moulds. For the past 30 years Sarah and her partner, composer Ron Nagorcka, have pursued a frugal life committed to biodiversity conservation in a forest in Northern Tasmania. Curiosity and attention to detail motivated Sarah to embark on two unique and significant studies in her native forest surroundings: a year-long study of the dawn chorus of forest birds; and the in-situ daily observations of the development and growth of slime moulds.

In 2005 Sarah began a year-long study of the dawn chorus of forest birds. Rising well before dawn, she made a minute-by-minute account of the time of their first and subsequent vocalisations, which species of birds were singing, their location in the forest, and their song type in different seasons. This study of the dawn chorus and her many hours of field ornithology equipped her to initiate 'A Sound Idea' in 2008. This innovative project to monitor bush and forest birds using digital sound recording devices involved over 90 participants from 160 locations in Tasmania. The recordings enabled Sarah to compile an aural record of habitats not previously surveyed for birds. It also fostered a greater appreciation of birds, their habitats and requirements among participants, many of whom had little or no previous knowledge of birds. Her latest publication, *The feathered tribes of Van Diemen's Land,* describes intriguing aspects of birds' lives never included in field guides, and is recommended reading for undergraduate students.

Since 2010 Sarah has been studying acellular slime moulds (myxomycetes) and has made hundreds of collections, many of which have been lodged in herbaria. Her detailed observational

Sarah Lloyd, with her Australian Natural History Medallion, and Nicola Williams. Photo Joan Broadberry.

studies have vastly increased our understanding of slime moulds, especially their ecology and diversity in Tasmania. Her book *Where the slime mould creeps: the fascinating world of Myxomycetes* has made this enigmatic taxon accessible to non-specialists both in Australia and internationally. The second edition was published in 2018. When Sarah collected a previously unidentified slime mould, *Alwysia lloydiae* was named in her honour. A website devoted to her slime mould research, 'Tasmanian Myxomycetes—searching for slime moulds in northern Tasmania', has numerous photographs, an illustrated glossary, clues to identification and 155 colour plates arranged in taxonomic order.

From her forest home, Sarah has communicated her passion and knowledge of natural history throughout Tasmania and the mainland. She is well known for her photographs and writings on natural history, especially for her self-published books, and as editor of the well-respected *The Natural News* published by

the Central North Field Naturalists. She writes regularly for various publications about the interactions between plants, fungi and animals and has a talent for telling interesting, factual, and readable stories about the natural world, underpinned with a conservation ethos. Her writings, photographs, field outings, presentations and workshops have inspired many others to pursue an interest in natural history.

Sarah excels at observing organisms in the field and making connections about food webs and microhabitats. Her books documenting the biodiversity at particular localities in Tasmania have led to the permanent conservation of significant areas of land. Sarah has also made significant contributions to natural history in Australia through leadership roles in community-based natural history groups, including the Central North Field Naturalists, Fungimap, Land for Wildlife, and Birdlife Tasmania.

Sarah's contribution to natural history, conservation and education extends over 30 years. Her extensive expertise is based on intensive fieldwork and detailed observation over many years. Through her numerous publications, articles, presentations and environmental advocacy, she has made a considerable contribution to Australian natural history.

The Medallion was presented to Sarah by the Vice President of the Royal Society of Victoria, Nick Williams, on 12 November 2018.

Maxwell Campbell
Secretary, ANHM Committee
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Australian Natural History Medallion Trust Fund

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Brendan Murphy	30
Alan Reid	6
St Arnaud FNC Inc	50

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The medallion is awarded annually to a person who is considered to have made the most significant contribution to the understanding of Australian natural history in the last ten years.

Maxwell Campbell
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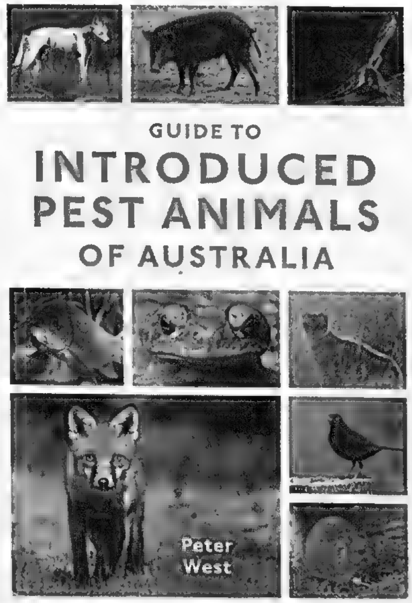
Guide to Introduced Pest Animals of Australia

by Peter West

Publisher: *CSIRO Publishing, Clayton South, 2018. 160 pages, colour photographs. ISBN 9781486305674,RRP $31.00 paperback, $32.00 e-book*



Australia is now home to many species of animals (i.e. mammals, birds, amphibians, reptiles, fish) introduced by accident or deliberately in order to make Australia feel more like England, or for food, or other (mostly questionable) reasons. Many of these species now are considered pests, causing significant damage to Australia's economy, natural resources, or human health and safety. It is generally fairly easy to find information on Australia's pest animals, especially well-known ones such as the European Red Fox; but such information is scattered, or may be provided by dubious sources, while information for identification is not always covered in existing field guides. Peter West has done an amazing job of compiling the facts about 60 of Australia's introduced pest animals and presenting them in *Guide to Introduced Pest Animals of Australia.*

This book is comprehensive, providing historical accounts and descriptions of 27 mammals, 18 birds, nine freshwater fish, two amphibians and four reptiles that have become established as pest animals in Australia. It also includes four species (Black spined Toad, Canada Goose, Corn Snake, and House Crow) that are considered to have high biosecurity risk. These species have been found in the wild in Australia on several occasions but have not become established.

For each species, information is concise and presented in just two pages. The same structure has been used in each instance: identification; distinctive characteristics; biology and history; distribution; habitat; damage and control options. It is easy to read and not complicated by scientific jargon. The text for each species is complemented by some beautiful, high resolution images, a map of the species' known distribution in Australia, and diagrams of indirect signs (e.g. tracks, scat) when appropriate.

As would be expected, species are grouped by taxa. However, within these groups, species are ordered alphabetically by common name. Therefore, it can take some time to find the species you are looking for if it has multiple common names (is it 'Red Fox' or 'European Red Fox', or just Fox?), or when 'feral' is used as the prefix.

The book is intended for a wide audience such as farmers, natural resource managers, land managers, pest controllers, teachers, students, field naturalists and wildlife ecologists. While it doesn't provide the depth of information that some of those audiences may hope for, it is a useful guide to introduced pest animals of Australia.

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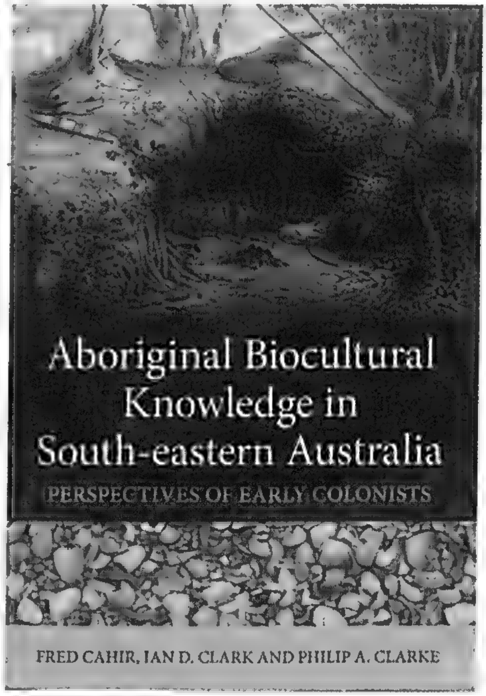
Aboriginal Biocultural Knowledge in South-eastern Australia: perspectives of early colonists

by Fred Cahir, Ian D Clark and Philip A Clarke

Publisher: *CSIRO Publishing, Clayton South, 2018. xxiv, 334 pages, ISBN 978148630614, RRP $69.95*



In recent years several popular books have drawn attention to a wide variety of practices and strategies employed by Indigenous groups in Australia to manage plant and animal resources. The general intent of works such as *The biggest estate on earth* (Gammage 2011) and *Dark emu* (Pascoe 2017), has been to awaken the Australian public to the fact that the Indigenous people of this continent were more than simple collectors and hunters. In similar vein, *Aboriginal biocultural knowledge in south-eastern Australia* puts before the reading public a wide array of published and manuscript sources that, collectively, reveal the vast body of knowledge and understandings thought to be held by pre-contact Aboriginal groups.

Biocultural knowledge runs deeply through all aspects of the life of Indigenous peoples. Recognising this, following the Introduction the authors have structured the contents of this book in 15 chapters, each of which group elements and details of knowledge appropriate to the chapter's heading. In this way, individual chapters focus on the spiritual world and cosmology; on health, well-being and housing; on food and water and the use of fire; and on transport and trade. The final two chapters deal with Aboriginal understandings of time and space. Equal coverage is accorded to each of these subject areas, which means the 300-odd pages contain an enormous amount of detail regarding the Aboriginal world.

Given the very wide scope of subjects covered and the number of sources consulted, it is not surprising to find the occasional oddity in text and references. For example, the textual reference 'Thomas in Victoria 1861' (pp. 218 ff.) is somewhat oblique and turns out to refer to something by William Thomas, contained somewhere within a Victorian Government report. In some cases (e.g. on p. 68), where the reference is to a comment cited in a later work, details of the original have essentially been hidden because only the later work shows up in the bibliography. There are also occasional quoted passages that have either no ascription or one that is erroneous.

It is puzzling too, and disturbing, to see a populist account of Aboriginal cultural practices and beliefs by Gordon Leckie presented without any qualification by the editors, as if it is of equal value to any of the other quoted sources. Leckie's unsourced account of an incident that had supposedly occurred about 60 years previously was published in *The Argus* in August 1932. Moreover, it is hard to know how

Leckie could be regarded as an 'early colonist' (*qua* the book's subtitle) or, indeed, fits into any of the categories of later researchers, e.g. ethnographers, anthropologists and scientists, elaborated by the authors in the Introduction, (pp. *xxi–xxii*). In fact, the book's subtitle is a bit misleading. While there are numerous references to observations from the 19th and early 20th centuries, and a good spread of quotes from these accounts throughout the text, on many occasions use is made of quite recent work by academics and professional researchers in relevant fields.

Notwithstanding these oddities, this book should be read by the widest possible audience. It will do much to correct the generally-held view of pre-contact Aboriginal life. For far too long, the Indigenous population has been seen as a culturally impoverished people, wandering aimlessly and living a hand-to-mouth existence through hunting and gathering. Hopefully, this volume will go some way towards redressing such widespread cultural and racial biases.

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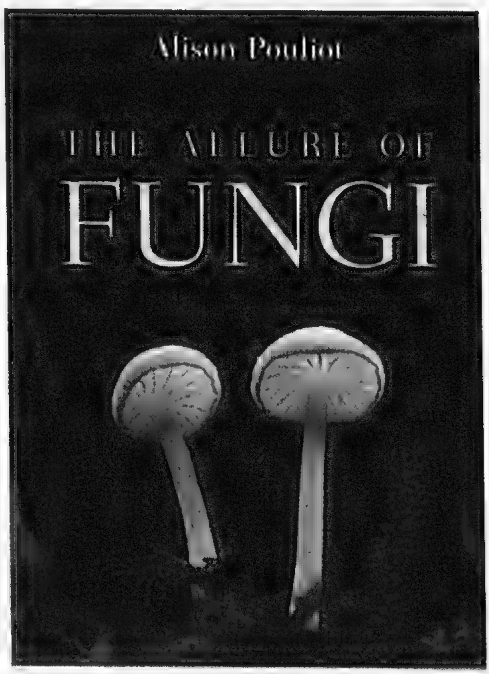
The Allure of Fungi

by Alison Pouliot

Publisher: *CSIRO Publishing, Clayton South, September 2018. 280 pages, softback, colour photographs. ISBN 9781486308576 RRP $49.99*



Alison Pouliot is a passionate, dedicated and erudite ambassador for fungi—a fungal phenomenon in fact. She is also a prolific freelance photographer and writer. Not content with a single fungus season in Australia, she migrates annually to the northern hemisphere for a second fungal fix. As a result, she has acquired a deep knowledge of her subject and a world-wide network of 'fungal folk' whose experience she can channel. During fungi season down south, she writes for *Wombat Forestcare Newsletter* and teaches at weekend community workshops throughout Victoria; her Woodend workshop that I attended back in 2013 piqued my own interest in fungi. Like the fungal cornucopias that she collects for these workshops, her website spills over with marvellous images that are as much a source of sensory and aesthetic delight as an aid to species morphology.

Pouliot's multi-layered book, *The Allure of Fungi*, is based on her ethnomycological research for her 2016 PhD thesis, 'A Thousand Days in the Forest'. It examines bio-cultural

knowledge about human/animal and plant relationships with fungi, drawing on fieldwork and studies of cultural traditions, government policies, scientific literature and fungal language. Her stories traverse Australia, Germany, Italy, Turkey, Sweden, Switzerland and the USA in search of 'fungal wisdom'.

Between 2012 and 2016, Pouliot spent a great deal of time living in the 'forest' and trying 'to understand why fungi are regarded so differently from other forms of life'. In Australia, she argues, British colonisation left a focus on fungal pathogens and a legacy of mycophobia that caused fungi to be deeply marginalised in our knowledge systems. Despite a cultural shift since the 1970s, there is still inadequate recognition for the 'megadiversity' of Australia's fungi and the vital role they play in the health of functioning ecosystems. This adversely affects fungi's inclusion in biodiversity conservation planning as well as the preservation of a handful of funded jobs for professional mycologists in Australia. To add weight to her observations, Pouliot 'collected' other 'voices' for scientific, philosophical and linguistic ideas, anecdotes, traditional knowledge and histories of relevance to her subject. Some came from long-time Field Naturalists of Victoria Club members, either through personal encounters or by reference to their publications. They include Maxwell Campbell (FNCV President), Ed and Pat Grey, Dave and Lyn Munro, Virgil and Jurrie Hubregtse, Paul George, and Tom May, Senior Research Scientist (Mycology) at Royal Botanic Gardens Victoria, a former FNCV president, and creator and immediate past president of Fungimap.

Pouliot believes that: 'Appreciating fungi is an art as much as a science' (p. 179). In her Prologue, she writes that 'aesthetic, sensate experience deepened by scientific knowledge' provides the best possibilities for understanding fungi (p. xi). Accordingly, her nine chapters are interspersed with eight themed photo essays that present different ways of 'seeing' fungi. To preserve their sensual and poetic quality, close-focus images are presented first as full-page, bled to the edges and without captions. Each photographic section is followed by thumbnail images with short captions about species, their location and thematic relevance. These alluring photos can be enjoyed on their own at an intuitive and emotional level. But Pouliot is not seeking passive readers and pretty pictures, so she issues a spoiler, warning that digitised second-hand fungal experience will not in itself develop ecological awareness or an ethic of care for the environment (p. 242–3). Rather, she intends these photos, along with her text, to raise a new ecological consciousness, 're-enchant' readers' imagination and encourage them to experience fungi subjectively and qualitatively where they grow.

Pouliot's cross-continental stories and anecdotes highlight differences between European fungal traditions and those of Australia. Chapter 8 discusses the differences between foraging for edible fungi, foraying for scientific purposes, and cultures where both occur simultaneously. For example, we learn that, unlike today, early Field Naturalists Club of Victoria members collected fungi equally for both purposes (p. 209). However, lack of engagement with Aboriginal cultures meant they were uninformed about traditional fungal knowledge. As local taxonomy increased in sophistication, fungi that had been named after European species began to be reclassified. Concerns about species ambiguity aligned with increasing conservation values shifted Club policy towards the citizen scientist model in use today. The few 'wild' species of 'mushroom' sold today in Australian markets and restaurants remain culturally determined by European traditions.

Pouliot doesn't discuss environmental science's genesis in the nineteenth-century academic discipline of Natural Philosophy. However, she does write about the complex ways in which cultural perceptions have informed science, and biological classification in particular. She recognises the challenges that Australia's hugely diverse fungi present for an 'all-encompassing species concept'—firstly, because they are largely undescribed, and secondly, because, as organisms, fungi confound conventional ideas about discrete individuality (Chapter 6). One such anomaly is lichen, which grows only as an algal (or cynobacterial)-fungal mutualism.

Fungi were among the first organisms on earth and are essential for regulating our biosphere. Pouliot asserts that the survival success of fungal alliances make them key to 'rethink-

ing environmental relationships in an era of rapid change' (Prologue). Chapter 1 'An Introduction to entangled worlds' introduces the hidden role of fungal mycelia in maintaining and changing habitats. It also draws attention to their metaphorical potential for understanding cooperative and connective systems more broadly. Pouliot cautions that too much attention on individual 'sporebodies' (fruiting bodies) for species identification may undermine our understanding of vital processes occurring between fungal mycelia and other organisms (especially plants). She concludes that any species-led approach to conservation planning that ignores these symbiotic relationships will produce poor outcomes for habitat as a whole.

The author has plenty more to say about species Red Lists, biodiversity conservation, legislative frameworks, forest management regimes, codes of collection, licensing systems, the shift from morphological to molecular taxonomy, and the value of amateur/citizen scientist research and Fungimap. She also has a clearly developed fungal philosophy that proposes fungi as exemplars for appreciating the 'indeterminate' and 'interrelated' and abandoning 'the illusion of constancy'. To accept Pouliot's determination that 'flexible fungi' will 'outlive the last *Homo sapiens* striving for efficiency and control' (p. 249) is inevitably humbling.

The Allure of Fungi tackles some big issues but Pouliot's linguistic exuberance is always entertaining. In this book you can learn about the fungal 'fizz' (p. 182), a mycological equivalent of the avian 'jizz'; or you can get down and dirty with coprophilic fungi in some particularly febrile 'dungscapes' (see 'Disco in a cow pat' pp. 66-68). Then there is the question of scale. 'Knowing about fungi is about doing time', Pouliot tells readers, referring to the years or decades before fruiting bodies may re-emerge. As forayers adjust to deep fungal time, she observes that some barely make it out the car park (p. 192). For those who like word play, she has games to counter 'the inadequacy of the fungal lexicon' to give meaning to the appearance or actions of fungi (p. 99). Challenging readers to come up with pertinent collective nouns, she begins: 'An accident of ink caps', 'an unveiling of *Cortinarius*' and 'a glow of *Omphalotus*'. You get the idea...

Despite this book's emphasis on cooperative networks, Pouliot's Australian fieldwork has been largely based in Victoria and, to a lesser extent other southern states, so not all active fungi groups in Australia get a mention. I would also have liked to see a fuller bibliography including all newspaper articles mentioned in her writing and references for all quotations. Minor quibbles aside, this fascinating and complex book will make a great addition to any ethnology, mycology, natural history or environmental science library. It conveys a wealth of important biocultural documentation through clearly communicated original writing and is a pleasure to read. I'm not sure that the environmental planners and policy makers who *should* read it will necessarily do so, but it may influence a younger generation who will fill these roles in the future. It also provides an imaginative counterpoint to Pouliot's influential community workshops.

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Bees of Australia: a photographic exploration

by James Dorey

Publisher: *CSIRO Publishing, Clayton South. 2018. 224 pages, softback, ISBN 9781486308491, RRP $49.99*

As a museum taxonomist, I look at insects under a microscope. I always feel privileged to work in this world of minute detail as I get to see amazingly intricate structures and colours of insects that are just not visible to the naked eye.

James Dorey's book takes readers to where I work and offers them a detailed snapshot of native Australian bees in superb colours and resolution.

James' stated aims for his book are 'intimacy and fascination'. He has delivered these very well.

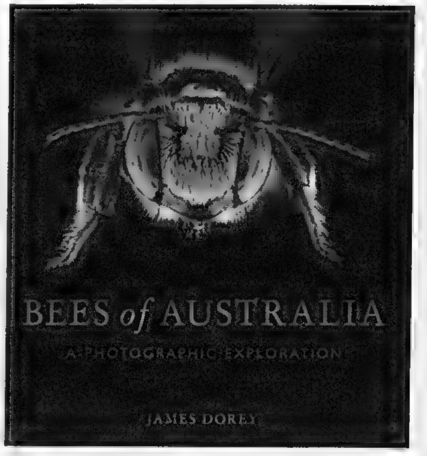
Currently, the named Australian bee fauna is divided into five Families with approximately 1600 species—estimates put true bee diversity between 2000 and 3000 species. *Bees of Australia* has images for only 73 species; however, all five bee Families are represented. A 'photographic exploration' was never meant to deliver an exhaustive species review.

Images for each species are spread across two pages with two to four images per species. The sex of the bee in each image is indicated and a life-sized bee silhouette is presented in the bottom right corner. Some images are of dorsal, lateral or ventral views while others are close-ups. Images are impressive and invite you to examine the detail.

Text for each species discusses the bee itself but then expands into broader discussions about the feeding or nesting habits, genetics, distribution or even taxonomic history for the species. James uses individual species to inform us about the Australian bee fauna.

The book is divided into chapters Australian State, with bee representatives from each state. Faunal and floral characteristics for each state are discussed and at the end of each chapter is an essay written by a variety of Australian bee researchers. Topics covered include the importance of bees, pollination, threats to our bees, social behaviours, finding and attracting bees and the importance of museums. All are excellent stories.

The hallmarks of good scientific writing are consistency and accuracy and, unfortunately, I



found a few minor inconsistencies and inaccuracies in the species text—some terminologies, facts, names and statistics are incorrect. The five-segmented bee 'foot' is variously called a tarsus (singular) or tarsi (plural). *Lasioglossum lanarium* is not the largest bee in that subgenus; *L. tamburinei* has that honour. There are almost 140 species in the subgenus *Chilalictus* rather than the stated 'roughly 50 Australian species'. *Pachyprosopis haematostoma* was described in 1913 rather than in 1915. *Quasihesma* is a subgenus rather than a full genus. And, I believe images of *Lasioglossum lithuscum* are actually of *L. lacthium*, based mainly on the large Laelapidae mite seen on the imaged bee.

A unique aspect of this book is that you can open it at any page and enjoy it as much as if you began at page one. Each species is its own entity and has its own story and yet the cumulative bee stories demonstrate the complexity and unknown state of Australian bees.

I highly recommend this book as a visual exploration of our native Australian bees.

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Tawny Frogmouth

by Gisela Kaplan

Publisher: *CSIRO Publishing, Clayton South, 2018, second edition. 168 pages, paperback, colour photographs. ISBN 9781486308163, RRP $39.99*

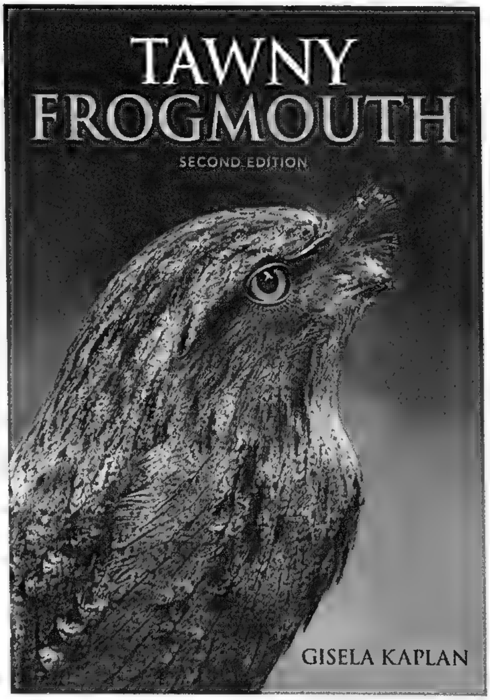
Tawny Frogmouths are charismatic birds and this book will be avidly picked up by people with even a vague interest in the birds. Anyone new to Frogmouths or delving into the literature on the species for a first time will learn much from this single volume. However, as with the first edition, upon which this is an improvement, it still needs to be read with caution (Debus, 2008; Minton *et al.* 2008). This second edition has less anthropomorphism, but is still anthropocentric and, for a book presented as a result of study, very subjective.

The format is similar to the original with the chapters titled: 1) What and where they are, 2) General anatomy, 3) The brain and the senses, 4) Daily life and adaptations, 5) Feeding and territory, 6) Bonding and breeding, 7) Development, 8) Emotions, vocal behaviour and communications, and a brief epilogue reflecting on the species' place in the urbanised world.

There are numerous photographs, all in black and white, some vague and difficult to discern. Whether the original material was poor or the publishers have not reproduced them well, the illustrations let the book down. Such a captivating bird should have been presented with more visual impact.

In the opening preamble the author describes her study as the largest on Tawny Frogmouths, and gives N = 158. Is that the number of birds, pairs or nesting attempts? If this is nesting attempts, then it is contradicted on p. 82, where a study of 253 nest records is quoted (Rae and Rae 2013) and that study now has over 500 nesting attempts from over 70 territories.

There is a wealth of information, but there are many statements that have possible alternatives or are just wrong, e.g. on p. 6, there are no Frogmouths in central and northern south America; p. 52, raptors do not eat eggs; and on p. 79 it is stated that Tawny Frogmouths are not cooperative breeders; this is contradicted by Rae (2014) who describes four such cases.



The author uses such terms as 'oddly' and 'surprisingly', strange words to use in a presentation of a study. Studies should be objective and researched, e.g. on p. 101 fig 7.5 'oddly' is used to describe how an unhatched egg was not removed by the parent birds. This shows a lack of wider experience, of Frogmouths and other birds. I have seen Frogmouths continue to incubate unhatched eggs while fledging chicks were in the nest. And I have seen unhatched eggs left in nests after chicks have fledged in numerous species from small passerines to eagles. If an author does not have such wider knowledge they should curb their use of qualifying terms such as 'oddly'.

Despite numerous flaws, the book is worth reading as an introduction to Tawny Frog-

mouths. However, beware of the personal approach adopted by the author, and refer to the original sources listed, or read more widely to form your own balanced account. Frogmouths are fascinating birds, not 'surprising'.

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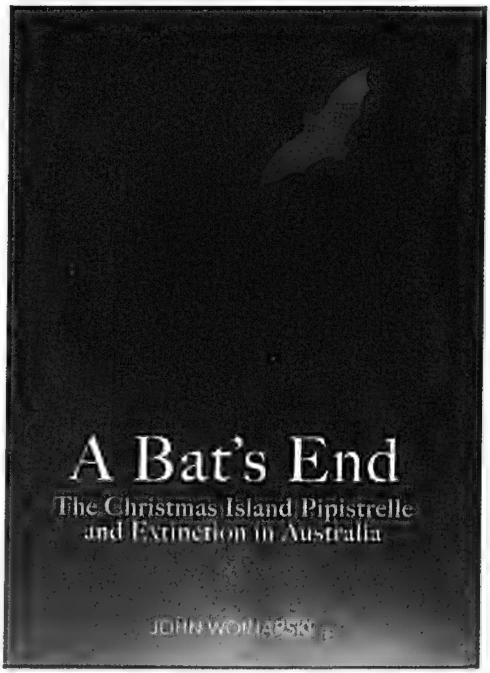
A Bat's End: The Christmas Island Pipistrelle and Extinction in Australia

by John Woinarski

Publisher: *CSIRO Publishing, Clayton South, Victoria, September 2018. 266 pages, paperback, ePDF, illustrations and photographs. ISBN: 9781486308637 RRP: $ 59.99*

In August 2009 the last tiny microbat endemic to Christmas Island went extinct, despite the Environment Protection and Biodiversity Conservation Act of 1999 and decades of reports warning of this impending disaster. This book provides an in-depth survey of the history of the ongoing degradation of Christmas Island ecosystems since phosphate mining started in the late 19th century. It also examines the failure to protect Christmas Island from further degradation and the extinction of its endemic reptile and mammal species, as well as the many other threats to the island, their complex interactions and the political tangles that delayed any serious effort at saving the bat until too late.

The author, John Woinarski, discusses the differences between continental and oceanic islands in the richness and endemism of their flora and fauna species, and their vulnerability to human intrusion. Mining for phosphate on Christmas Island commenced in the 1880s, leading to the steady ongoing destruction of this small island's rainforest, a series of phosphate companies acting as its effective government for over a century. Its refugee detention centre was built in the 1990s, in the main surviving foraging area of the pipistrelle, by then



already in rapid decline. Even its famous red crabs are seriously in retreat.

Woinarski carefully examines the damage by Yellow Crazy Ants, Wolf Snakes, Giant African

Snails and rats, along with the hunting behaviour of the Chinese/Malay mine workers. A national park covers half of Christmas Island, but is poorly resourced. Mass aerial poison drops have twice reduced the ants by 99%, but they always recover and resume their devastation.

Study of the pipistrelle since the 1980s has been episodic. Increasingly urgent calls for conservation of the rapidly declining pipistrelle brought a crisis response when it was too late, after years of dithering. Woinarski closely compares this with extinctions on other islands and examines the difficulty of identifying the main causes of declines in multi-problem islands.

A chapter on the drivers of extinction examines mining, the many invasive species, hunting, the detention centre, the policies and management failings of the remote, overstretched National Parks Service, and ethics in relation to conflicting 'landscape-scale' and 'species-scale' conservation policies.

Ten people deeply involved in the effort to prevent the extinction contributed personal views, including several bat biologists traumatised at the futility of their efforts, and the lack of action by park managers and bureaucrats. Woinarski concludes that the main culprit was the tree-climbing Wolf Snake, its spread across Christmas Island coinciding closely with the bat's retreat. Many aspects of human damage to fragile island ecosystems are explored (in all 532 references). Woinarski offers 10 recommendations for preventing more extinctions. These advocate taking moral responsibility for nature, widening our focus away from economic tests of social success, strengthening legislation to really protect biodiversity, making government more accountable, and increasing spending on environmental research and management by an order of magnitude.

A very thorough survey of the widespread, growing problem of extinctions, *A Bat's End* is also highly readable, well illustrated and indexed, with many lessons for conservation management.

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Secret Lives of Carnivorous Marsupials

by Andrew Baker and Chris Dickman

Publisher: *CSIRO Publishing, Clayton South, Victoria, August 2018. 328 pages, hardback, colour photographs and illustrations. ISBN: 9781486305148. RRP: $140.00*

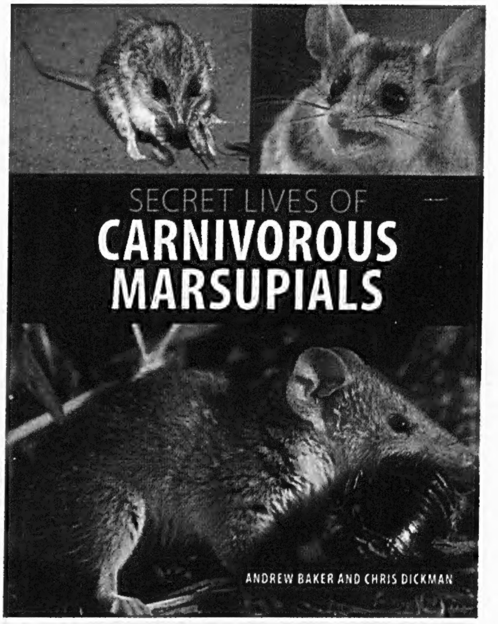
The authors of this publication are leading researchers in Australian mammalogy, with an extensive catalogue of published works. Chris Dickman is a world expert on marsupial ecology, reproduction and conservation, with particular focus on carnivorous marsupials over his 30-year career. Andrew Baker has extensive expertise in systematics, taxonomy and genetics, and has recently focused on identifying previously undescribed carnivorous taxa of the *Antechinus* genus. Together, they have distilled decades of research and investigation into an extensive, detailed reference on the history and habits of the world's carnivorous marsupials.

The *Secret Lives of Carnivorous Marsupials* spans the carnivorous marsupials of Australia, the Americas and New Guinea. Although not specifically aimed at an academic audience, it will serve as an invaluable key reference for wildlife researchers, postgraduates and wildlife managers. It is supported by considerable research, sourced not only from academic publications but also from unpublished reports and the authors' and contributors' experiences and observations. In addition, for undergraduate students, naturalists and other readers, the book provides a wealth of information on these 'secretive' and generally poorly known animals.

The book describes the characteristics and diversity of carnivorous marsupials and has a guide to the 136 living species accompanied by excellent photos, some never-before-seen, particularly those of American marsupials. The biogeography of marsupials, including their radiations in Australia, New Guinea and South America and their relationships and systematics are covered in detail. Fascinating information on fossil carnivorous marsupials, including extinct predators such as marsupial lions, wolves and sabre-toothed kangaroos, is accompanied by high quality artists' impressions and figures. Readers are also taken on a guided tour of the pioneers who discovered carnivorous marsupials, from early European explorers of the 1400s through to famous collectors, naturalists and taxonomists in the 1700s to mid-late 1800s and early 1900s (e.g. Oldfield Thomas and John Gould).

The unique lifecycles and mating practices of many carnivorous marsupials are described for species across wide-ranging habitats, including forests, rocky outcrops and deserts. Their unique methods of hunting and foraging for prey are highlighted, together with morphological adaptations for food processing. Finally, the challenges of conserving our disappearing marsupials from the dire consequences of burgeoning human populations, environmental degradation and climate change, are covered, along with detailed information on assessing conservation status, conserving and recovering small populations, and new ideas for controlling invasive species and predators.

A major feature of the volume is the detailed descriptions of extensive fieldwork undertaken by dedicated scientists and researchers. Short vignettes include personal accounts of fieldwork and descriptions of its personal challenges: leeches, storms, confrontations with illegal hunters and cultivators. Significantly, they also show how chance and curiosity-driven science still play such important roles in understanding carnivorous marsupials, and result in unexpected outcomes that alter our understanding of them. These descriptions also capture the dedication,



wonderment and, indeed, empathy the authors and scientists have for these unique animals.

During my professional life as an academic I have collated much information from diverse sources for presentation to undergraduate and postgraduate students; this volume has comprehensively updated the carnivorous marsupial knowledge base, and its extensive references are a wonderful source of primary work collated by the authors over many years.

Secret Lives of Carnivorous Marsupials provides an important insight into the history and habits of the world's carnivorous marsupials, enabling readers to more fully appreciate these unique and secretive animals. The authors contend that without such knowledge little can be done collectively to intervene and address the threat of extermination currently facing many carnivorous marsupials. Who can argue with that!

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